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MECHANICS—INTRODUCTORY.

By Prof. COLEMAN SELLERS.

[Delivered at the opening of the course of lectures on Mechanics, Friday, November 9, 1883. Revised from report of Phonographer.]

LADIES AND GENTLEMEN:—The order of lectures that has been announced for the season of 1883–1884, calls for one by me, noted as "Introductory on Mechanics," rather an indefinite title I admit, but I do not want you to expect a formal lecture on Mechanics; I desire to speak in the first place about the lecture course and about methods of instruction. Bear in mind please, that about sixty years have passed since the first lecture was delivered before the Franklin Institute. It was on the 28th of April, 1824. At that time our Institute had no abiding place. Through the courtesy of the Trustees of the University of Pennsylvania, the old academy on south Fourth street was loaned to the Institute and many of its lectures were delivered there. The first course was a series on Mechanics, Natural Philosophy and Chemistry, and Architecture, it was attended mainly by members, sons of members and apprentices who desired information that could not be obtained at that time in the public school. To these early lectures no women were admitted. It was not until the second course, when lectures on Natural History were added to the list, I presume by Dr. Godman, that women were admitted to these lectures on Natural History; and from that time to the present nearly all lectures have been honored by their presence. It is very pleasant to think that so many

of them desire the kind of instruction that has been given in this place.

If we consider what was the state of the Arts at the time the Franklin Institute was organized, and what the state of the Arts now is, we can form a better idea of what lecture courses were best adapted to the wants of the members in those days, and what is expected of the lectures of the present day.

In business, we may measure the success of mechanical enterprise by the success of the railroads. When railroads are doing a paying business the mechanic arts are prosperous. I think it may be very well to take the railroad as the standard of the progress of the United States during the sixty years that have elapsed since the first Franklin Institute lecture was delivered. Let us glance backwards to the condition of the railroads sixty years ago. It was in 1824 George Stevenson one of many active workers in the same direction, began his earnest work to induce the people of England to build the Liverpool and Manchester Railroad. In 1825 he was laughed at for his wild scheme. We can find in books in some libraries an account of the bubbles talked of in 1825, among which was a contemplated railroad from Liverpool to Manchester. The term locomotive as the name is now applied to a machine was not then invented. It was not until 1829, within the lifetime of many who are now present, that the first railroad for freight and passengers operated by steam was opened. Before that time, Oliver Evans, in 1804, it is true, carried through the streets of Philadelphia, a dredging scow and propelled it on land and water by steam. Oliver Evans died in 1819. And Hedley had proposed smooth wheels on a rail in 1813.

Oliver Evans said the time would come when we would start from Washington, breakfast in Baltimore, dine in Philadelphia, and sup at New York, and attain a speed of forty-five miles an hour, as fast as the "speed a bird flies." In 1824 the world was not ready for steam on railroads. In 1825 they laughed at the proposition of traveling fifteen miles an hour. They insisted that the trains be slowed down so as not to interfere with the stage coaches, and so destroy an active industry. From that time to the present, what has been done? Our continent is crossed from ocean to ocean by this iron rail, and the railroads of the present represent a vast accumulation of concrete thought. They may, in the gambling saloons of Wall street, represent only stock value, and there are people who think of

them only as of the amount of money they represent in the stock gambling. To those who are assembled here, in the Franklin Institute to hear a lecture on Mechanics, the railroads are the embodiment of thought, of mental effort almost too great for mind to grasp. See the Pennsylvania Railroad we are all so proud of, and the engines that eliminate space in speeding such rich freight across the continent we may say, from the Atlantic to the Pacific. As the railroad was in 1824 as compared to the railroad in 1883, so were the intellectual needs of the mechanics compared to his requirements to-day. When the Franklin Institute was founded it was intended that it should be a school for the mechanic, who desired instruction which could not be obtained in the public schools. Every effort was made to impart the instruction needed in the best and surest manner—lectures and special schools did this.

The Mechanical Engineer, must not only be a physicist in the broadest sense of the word, but there is scarcely any limit to the knowledge he must bring to his use, sooner or later, in his life work. Some one says that the engineer must understand matter and apply common sense to its use, to this add a clear knowledge of the laws that govern matter in motion. The early course of lectures, before the Franklin Institute were of an elementary character. They were the best for the purpose and could not be obtained at any other school. What has been the result of the work of the Institute? Gradually our people have begun to recognize the need of giving industrial education given in the public schools. You must bear in mind the High School of Philadelphia is the direct outgrowth of the Franklin Institute. At the present time it should be possible for the elementary information, formerly given only by the Institute, to be obtained free in the public schools. At the same time, there is reason why our lectures should still be delivered.

The class of lectures that may now do the most good are, perhaps, not elementary or primary in character. Lectures must entertain and instruct and suggest lines of thought and inquiry. In laying out the present course, several important elements have been considered; in the first place, many believe it is possible to have taught in the public schools the underlying principles of manual labor. I do most certainly think the use of tools, so needful in the trades, can be taught without teaching any trades. The use of tools may be very judiciously introduced in the course of study.

In the early history of our country the work-shops were not very far removed from the schools. It was almost impossible for a young man to attend school from one year's end to another. He had to work in the shops, on the farm, and attend school but part of the time and what was the result of such training? Good solid men live yet to attest its merit. What is the result of the later system of training of the public schools? The students are separated entirely from manual labor and their heads only trained, they get what makes them traders, doctors, lawyers; certainly not mechanics. Little is given to the students of the public schools below the high school, that will enable them to enter the work-shops, with the ready means of applying their school knowledge to practice. There is a very simple reason for this; the teachers are not mechanics; they are not expected to be; the scholars can more easily learn those things that relate to buying and selling than what relates to mechanical arts. It may seem very easy to apply the methods and rules learned at school to the practice of the machine shops; but you must bear in mind the instruction given in the public schools is only on the plane of the teacher or the writers of the books used in the schools. Teachers in the public schools should understand the principles of mechanics. The same rule of three, illustrated by examples pertaining to trade, is used by the mechanic in determining the speed of machines and calculating the size of pulleys to drive the machines—but the boy is not given examples in the direction of mechanics.

The examples prepared for the scholars have little or no reference to the uses of the mechanic. In the limited time of a lecture, it is impossible to present the full argument in favor of handicraft instruction. I have said some of the mechanical operations may advantageously be taught in the schools. A rest from the head-labor and the education of the hands will make the brain stronger; as an experiment in the direction of teaching the use of tools without teaching trades, Mr. Joshua Rose has been selected to deliver a course, beginning on the 16th of November. Mr. Rose is a very skillful English machinist who came to this country some years ago and has of late been writing many interesting papers in the scientific journals on mechanical manipulation; he does know how to use these tools.

Immediately after Mr. Rose has finished his course, Prof. A. J. Parker will deliver a course of lectures on Vital Dynamics, or the Laws of Mechanics, as applied to walking, running and swimming.

Great interest centres in what relates to the human frame, the animal frame and the laws that govern their motion, and modern science has thrown much light upon this subject.

It has been thought best to bring some of the interesting novelties in mechanic arts before the Institute in the lecture course. One branch of the mechanical arts, boiler-making, has in England and the Continent received a great deal of attention by engineers. Hydraulic power has taken the place of manual power and the riveting of boilers and ship plates is largely done by machinery in place of hand work. In order to have this brought before the Franklin Institute we have asked Mr. James Platt, who is familiar with the subject and is now visiting this country, to give a lecture which will be delivered on the fourth Wednesday of this month. Later, Mr. Henry R. Towne, of Stamford, Conn., son of the late Mr. John H. Towne, the founder of the Towne Scientific School of the University of Pennsylvania, will deliver a lecture on Crane Construction. The reason for this subject being selected is, that what tends to aid the ready handling of merchandise and heavy weights, as in the terminal facilities of railroads, merits careful attention. It was thought advisable to request of him this lecture so as to present the latest development of that industry in America, and as suggestive of the more extended use of power cranes.

Two lectures will be given by Mr. George M. Bond, of Hartford, Conn. He is connected with the well-known Pratt & Whitney Company, and has charge of some novel measuring machinery perfected by them. There was a time when the two-foot rule, rudely made, answered the mechanic's purposes. There is a saying in Germany that every hair in a carpenter's head is one-eighth of an inch in diameter; meaning, that a carpenter does not require closer measurements than one-eighth of an inch, not nearly so fine measurements as a machinist does, because he fits the joints to plan. The terms "full" or a "little full scant" indicated variations from exact size, but a little while ago; a vast change in regard to accuracy of measurement has now come over the whole mechanical industry. Now there is an attempt with almost all machinists to make machinery interchangeable in its parts. One branch, however, may need only coarse measurements while others need the most minute measurements and accuracy. The ordinary two-foot rule may answer for many purposes and be very convenient, but its use is limited. We have little devices

given to us for use in the work-shop which give a ready measurement as fine as the one-thousandth part of an inch, (showing one of the screw caliper gauges made by the Victor Manufacturing Company.) This gauge is graduated, each division representing the one-thousandth part of an inch. Any substance placed between the two points of contact in this gauge, and the gauge closed upon it, can be measured to the one-thousandth part of an inch. (Then showing a somewhat similar instrument made by Heilmann, Ducommunn and Steinlen, at Mulhouse, Germany.) Here is an instrument made, not purposely to measure, but rather to show the perfection which certain machine tools have reached in doing certain kinds of work. It holds between the contact pieces five cubes, each one being twenty millimetres square; these cubes have not been touched by the hand of a workman with a file; they are machine made to size only. Five of these cubes placed in a row measure one hundred millimetres in length. The screw in this instrument is one of the few examples in the country of a screw cut to the millimetre pitch. The circumference of the collar which surrounds the screw is divided into one-hundred parts, while in the case of the American instrument, you read to the one-thousandth part of an inch, here you read to the one-hundredth part of a millimetre, say to about $\frac{1}{2500}$ of an inch.

Mr. Bond is connected with an establishment making gauges of various kinds, and they have perfected a machine, the Rogers and Bond Comparator, which reads sizes more closely and which can compare sizes more closely than anything heretofore proposed. He will deliver a second lecture on Standards of Length as applied to Gauge Dimensions.

For one night the subject is yet unannounced, this it is expected will be well selected. These are the lectures which are to form the Course on Mechanics.*

As to the utility of lectures, as compared with books on the same subject, I desire to say a few words. When I speak to you in the lecture room, if you do not hear or do not understand, or if I make a verbal mistake, the result is you draw wrong conclusions. If I sit down and deliberately write my thoughts and publish them for you to read at your leisure, you will receive your information better and

* The unannounced lecture was delivered by Mr. Coleman Sellers, Jr., February 8; the subject being Mechanical Drawing—Free-hand drawing as applied to mechanics was illustrated.

more thoroughly than in a lecture room; so thinking men prefer to read lectures, not to hear them.

The lecturer fails in as much as he may make mistakes in his lecture—mistakes in words. The hearers may misunderstand him, their attention may be distracted by something else going on in the room, and when they bring their thoughts back again to the lecturer they may have forgotten a good part what preceded and it cannot be recalled. I once listened to a lecture on the Spectroscope, one of the best lectures I ever heard. The lecturer, a most able scientist, described in the introduction to his lecture a simple form of spectroscope, telling how two cheap spy glasses combined with a simply formed prism could be united to form an effective working spectroscope. Then he showed more perfect instruments of the kind, explaining how they were used. Finally he told of what wonderful discoveries made by means of the spectroscope, winding up with the assertion that by means of this simple instrument we are enabled to reach out towards the stars of the heavens and, grasping them with the hands of science, to analyze them as readily as we can the sands gathered on our seashore.

The lecturer satisfied me as he did many more who heard him, but a very bright and skilled machinist came to me the next day to ask how to make a spectroscope—explaining that his interest in the instrument was excited only when he learned what it would do—and, as this knowledge came after the description of it, he could not recall what had been uninteresting in the beginning. Had the lecturer told what the spectroscope enabled us to do and shown how it was used, and afterwards told how it could so easily be made, a better result would have followed so far as the teaching power of the lecture is concerned. The same lecture, however, published would be in proper sequence as delivered for, in a book, one can go over and over again the points needing most thought or refer back for what has escaped attention at the first reading.

It is possible at the present time, with the abundance of books at our command, for all who desire to study the mechanic arts, to do so better from books than from words spoken in the lecture room. I have here a book I advise all young men to purchase or to get from the library and read—"Experimental Mechanics," by Prof. Ball, is the title of it. Those lectures were delivered in Ireland and are models of clearness. The pictures in this book take the place of experiment.

The excuse for scientific lectures is that we are able to show experi-

ments and enable people to see what cannot be understood in descriptions. Good illustrations go a long way towards making the book better than the lecture. A single sketch will tell me a great deal more than many pages of printed matter will do. In this work of Prof. Ball's, the student is carried through many of the laws that are necessary for the mechanic to understand, that he must understand, that are absolutely necessary for him to really know.

Prof. Ball, during this course of lectures, delivered one full of interest on what is known as Weston's Differential Pulley Block or Hoist. I have one of them here this evening and, while I cannot devote to its explanation as much time as Prof. Ball did, I want to make it useful as an illustration of the care that must be exercised in drawing conclusion from experiment. A strong point in Prof. Ball's course of lectures is the clear and precise manner in which he explains the subject he has under consideration, and the lecture on the Differential Pulley Block is a fitting sequel to those preceding it, which carried the student step by step through the laws of mechanics that must be known to enable one to fully understand the operation of this simple machine for hoisting.

I cannot go over the same ground, but I can in a few words explain what is meant by velocity ratio and its relation to power actually transmitted through or by a machine. Every boy learns early in life that if he wants to ride see-saw with a companion who weighs as much as he does, that a board balanced over a fence rail will be ready to take boys of equal weight on its ends, and that each will ride through an equal arc, or that each one will ride as high as the other. If, however, one boy is heavier than the other, he soon learns that the board must be readjusted to the conditions of weight, and that the heavy boy will not only be nearer the fence but will not rise so high as the one who is farther from the fence on the long end of the board. If one boy weighs just twice as much as the other, the distance of the heavy boy from the fence will be just half the distance that the lighter one is from the fence on the other side. In the see-saw ride the heavy boy will rise and fall just half the distance that the lighter one does, and he will travel through the air in rising and falling at just half the speed of the lighter one. The velocity ratio of the two will be as two is to one.

The governing law in this case covers all kinds of levers and all mechanical motions. If one part of a hoisting machine of any kind to which the power is applied travels through a distance which is

found to be a certain number of times the distance through which the load lifted travels in the same time, that number expresses the velocity ratio which holds in that case. If, in the case of an ordinary block and fall, the rope pulled to raise the weight requires say five feet to be overhauled to raise the weight one foot, then the velocity ratio is five to one. If it was not for friction, velocity ratio and power ratio would be the same. Thus, if it requires five feet of rope to be overhauled to raise a weight one foot, then one pound applied to the hoisting rope should raise the weight of five pounds; but it will not do it. The friction of the machine of the pulleys and the friction of the bending rope—the power it takes to bend the rope—these and other matters diminish the power obtained from any given force, and the theoretical power required to hoist the given load divided by the actual power comes to be called the efficiency of the machine. If, for example, in the case of the hoisting device of five to one velocity ratio, it is found that it requires two pounds passing through a space of five feet to raise five pounds one foot high, in place of one pound moving the same distance to do the same work, then while the velocity ratio is five to one the efficiency of the machine is only one-half, and fifty per cent. of the power has been lost in friction. Friction thus stands in our way, and in some cases it stands very much in the way. It stands right square in the way of all who try to make perpetual motion machines. Friction is not, however, always objectionable, it is in many cases the thing sought for. We seek to diminish friction by many means when we do not want it, we seek to increase it when it is an advantage to us. The locomotive, that thunders across the continent with its wealth of life or freight, bites the steel rail on which it travels with the teeth of friction. It is friction and only friction that holds it to the smooth rail. It may require ten tons to cause a fifty-ton engine to slip with its locked wheels on a smooth rail; if so, then the fifty-ton engine has nearly ten tons of power in its pull on the train that it hauls along the smooth rail of the road.

The Weston differential pulley block I now show you has a load on it of one hundred pounds and the velocity ratio of the machine is sixteen to one. That is

to say, to raise the load one foot I must overhaul sixteen feet of the loop which serves as a hoisting loop. I pull sixteen feet of chain over the sheaves to hoist the load one foot. If friction did not prevent I should hoist the load of 100 pounds with a force equal to one-sixteenth of the 100 pounds, that is, with six and one-quarter pounds, but I will now apply a spring-balance to the hoisting rope and measure in that manner the force that must be exerted to lift 100 pounds. I am now exerting a pull of 22 pounds and the load has not started, but when in motion it seems to require a pull of about twenty pounds to keep up the motion. If now we divide the theoretical power required to hoist by the actual power required, that is to say, if we divide 6·25 by 20 it will be seen that the efficiency of the machine is ·31 per cent. and there is therefore a loss in friction of 69 per cent. While this loss seems great it has its compensating advantages, for you will observe there is no tendency for the load to overhaul when I no longer pull on the hoisting chain; in point of fact, when I desire to lower the weight I must actually exert some power on the opposite loop of the chain to haul the load down. I do not exert very much force, it is true, to lower, but still the force is appreciable. Now we sum up the advantages of the machine thus: It is simple, not likely to get out of order, will not overhaul, but will hold any amount of weight consistent with the strength of the machine without any danger of the weight running down. Safety is one of its great advantages. These machines, made in this country, by the Yale & Towne Manufacturing Co., of Stamford, Conn., have come into very general use.

I will now take down the Weston differential pulley blocks and will hoist a load with a device made in this city by Messrs. Edwin Harrington & Son. In this machine the power to hoist is obtained by means of a worm or endless screw working into a worm wheel, and two sprocket wheels, one on each side of the worm wheel carry the chain to which the load is hung, which, while it forms a loop has no differential motion as in the Weston hoist, but each revolution of the worm wheel hoists the load through a space equal to the circumference of the sprocket wheels measured at the centre of the chain that passes over them. A separate small chain passing over a sprocket wheel on the shaft of the worm or endless screw

serves to operate the machine in hoisting. Thus if I pull on one side of this loop or endless chain I may with a motion of six feet raise the load one inch. I will not be particular as to the exact ratio. I have 35 pounds hanging on the chain hook, and you will observe that three pounds applied to the small chain barely hoists that load. Theoretically, based on the velocity ratio of the machine, less than one pound should have hoisted the load, and the efficiency of the machine is 27 per cent., the loss in friction being 73 per cent. It does not seem liable to run down with any load, and a given weight is hoisted with less effort than on the Weston machine because the velocity ratio is greater, but the load is hoisted slower.

This machine is simple, not likely to get out of order, works very smoothly, in fact more smoothly than the one we first tried, and will carry a load without any tendency to overhaul. In both cases, you must remember, there is more than 50 per cent. lost in friction. Prof. Ball concludes from experiments similar to those shown you this evening that the principle involved extends to other mechanical powers and may be stated generally, thus: "When rather more than half of the applied energy is uselessly consumed by friction, the load will remain suspended without overhauling." This general statement is clear and conclusive, and we are led to believe that in all hoisting machines if there is a loss of more than half of the applied energy in useless friction the machine can be depended on to hold the load without any tendency to overhaul.

Now follow me, please, in another simple experiment. I have had made for illustration this evening a crude hoisting machine involving a series of spur wheels gearing into one another in such a way that power applied to one end of the series will serve to hoist a load at the other end of the series. The velocity ratio is such that but for friction we might raise a load of five pounds with $\frac{8}{10}$ of one pound, but it requires two pounds to lift five pounds, so that the efficiency of the machine is 40 per cent., and the loss in friction is 60 per cent. In this case, with a loss of friction of more than 50 per cent., according to Prof. Ball's statement there should be no danger of allowing the load to hang on its hook without any applied power at the other end of the series. Now observe what when I take away the two pounds required to lift the load. You see the load overhauls fast enough, and what is more, the heavier the load the faster it will overhaul. In this case I have simply strung a series of wheels together until their multi-

plied axle friction is more than 50 per cent. in the whole. But as each pair of the series is capable of overhauling, the whole will overhaul with a load sufficient to overcome the friction of the machine. If this was not the case, and ordinary clock series of wheels could not be depended on to run, for it is the load applied to the drum of clock series and which has been wound up, running down operates the clock. Let us now for a moment think how Professor Ball has erred. His experiments warrant his assertion, and what he says is strictly true as regards all similar mechanical powers involving few parts. Had he said, in any mechanical pair, that is, machine consisting of two parts, if rather more than 50 per cent. of the applied energy is lost in useless friction then the machine will not overhaul. He has made a mistake in generalising from too few experiments. The converse of his rule is true as applied to any machine of the kind, viz.: If a hoisting machine is so constructed as not to overhaul, and the reason for its not overhauling is from loss of applied energy in needless friction, it is safe to infer that the total loss in friction is rather more than 50 per cent. Thus in the case of a screw working in a nut without either collar friction or end friction, like a step. We have an example of this familiar to you all in the screw and nut of the elevating music or piano stool. The load resting on the stool does not cause the screw to run down, friction alone prevents its so doing; it is safe to infer that the loss in friction is at least 50 per cent., and if you attempt to raise a load on the stool by screwing it up under the load, the force you apply to do so will be more than double what the velocity ratio would call for.

I do not use this error in Professor Ball's admirable lectures as an example, this evening, with any intention of speaking disparagingly of them, but to give you an idea of the care that must be exercised in drawing conclusions from our observation of facts, and at the same time show you how much more certain we can be about what we can read with care, than we ever can be about what we think we have heard a lecturer say.

(To be concluded.)

Encke's Comet.—Backlund finds that the empirical correction which is required to perfect the theory of Encke's comet, after being nearly constant for fifty years, experienced a considerable variation. The average acceleration of the mean movement, between 1871 and 1881, was only about half as great as the value found by Encke and Asten for the period from 1819 to 1865.—*Comptes Rendus.*, June 11, 1883.

INITIAL CONDENSATION OF STEAM CYLINDERS.

By WILLIAM DENNIS MARKS,
Whitney Professor of Dynamical Engineering, University of Pennsylvania.

In previous papers published in this JOURNAL it has not been assumed that the actual steam from boiler per horse-power per hour was other than directly proportional to the steam registered by the indicator.

It may be a constant fraction or it may be a different fraction for each point of the stroke at which steam is cut off.

We have as yet no experimental proof of what the ratio is that exists between the actual steam and the indicated steam.

It may be of service to call attention to hypotheses as to what this ratio may prove to be.

Let d = the diameter of the steam cylinder in feet.

Let s = the stroke plus clearance of the steam cylinder in feet.

Let V = the volume of the cylinder in cubic feet = $\frac{\pi d^2 s}{4}$.

Let e = the fraction of the volume of cylinder at which steam is cut off.

Let N = the number of strokes per minute.

Let T_b = the temperature of initial steam.

Let T_e = the temperature of exhaust steam.

We can then say that eV is the volume of steam existing as vapor in the cylinder at the instant of cut-off.

To this volume of steam as vapor must be added a large quantity which is condensed during the entrance of the steam *before expansion begins.* What happens to the steam during its expansion is a matter of comparatively small moment, since we know that the curve of pressures is quite as nearly an equilateral hyperbola, as any other curve within limitations which have been established quite independently of any assumptions regarding the ratio between actual and indicated steam. (See this JOURNAL, December, 1883.)

Statements as to the enormous amount of initial condensation seem almost incredible, and yet it is difficult to account for the great discrepancy which does exist in many cases on any other hypothesis.

In nearly every set of experiments made upon the steam engine there has been some missing link in the chain of evidence, and as a

result the statements made cannot be proved, nor have the doubters been able to disprove them.

If we make the assumption that the initial condensation is proportional to the surface presented up to the moment of cut-off, we have

$$\text{Area of piston and cylinder-head} = \frac{\pi d^2}{2}.$$

$$\text{Area of cylinder walls} = \pi des.$$

$$\text{Their sum} = \pi d\left(\frac{d}{2} + es\right). \tag{1}$$

If we assume that the condensation is also proportional to the difference in temperature of initial and exhaust steam, we have

$$(T_b - T_e) \tag{2}$$

If further we assume that the condensation is proportional to the time of exposure, we have

$$\frac{1}{N} \text{ minutes} \tag{3}$$

for the time of exposure of the cylinder to exhaust steam, and

$$\frac{e}{N} \text{ minutes,} \tag{4}$$

for the time of exposure of the walls to initial steam.

Since the exposure of the exhaust is much longer than that of the initial steam, we can assume as the more tenable hypothesis that the cylinder walls already let down in temperature by a low terminal pressure, lose heat to a depth proportional to $\frac{1}{N}$.

The great pressure and high temperature of initial steam will then in all probability cause so much more rapid condensation of initial steam as to render its lesser time of exposure comparatively unimportant.

The weight of steam indicated each stroke is

$$\frac{62\frac{1}{2}\, eV}{S} = W \tag{5}$$

in which S is the specific volume for the pressure at cut off. If now we assume the actual steam from boiler used in one stroke to be pro-

portional to difference of temperatures, area exposed, and time of exposure of initial steam, plus vapor; we have for steam from boiler

$$W_s = 62{\cdot}5\,\frac{eV}{S} + \left[\left(T_b - T_s\right)\pi d\left(es + \frac{d}{4}\right)\frac{e}{N}\right]C \qquad (6)$$

If we assume $e = \frac{1}{4}$ or less $\frac{d}{2}$ becomes $\frac{d}{4}$, or less, in which C represents the weight of steam condensed by a difference of one degree Fahrenheit in an iron surface of one foot area exposed for one minute.

If, as seems more probable, we assume that the condensation is proportional to the time of exhaust, we have

$$W_s = 62\tfrac{1}{2}\,\frac{eV}{S} + \left[\left(T_b - T_s\right)\pi d\left(es + \frac{d}{2}\right)\frac{1}{N}\right]C. \qquad (7)$$

If we let $r = \frac{W_s}{W}$, we then have from eq. (7)

$$r = 1 + \frac{S(T_b - T_s)}{62\frac{1}{2}\,N}C\left[\frac{4}{d} + \frac{2}{es}\right]. \qquad (8)$$

The reason for giving the preference to formula (7) is that the depth of cooling is probably more influenced by the time of exposure of the exhaust, and that the condensation of initial steam would seem to be instantaneous.

The order of events would seem to be as follows, the engine having attained its regular speed, and the cylinder an average heat.

The entering steam touching the interior of the cylinder condenses instantaneously and warms it up to a temperature of the steam, this warmth proceeds to a depth proportional to the depth already cooled by the exhaust, the steam then expands after cut-off, falling in temperature and losing heat, first by warming up the cooled cylinder walls, second in doing work, however the heated iron of that part of the cylinder exposed before cut-off, gives up heat and vaporizes the condensed water of initial condensation in the attempt to equalize the temperatures throughout the cylinder, which is effected by a transfer of condensation following the motion of the piston-head.

At the end of the stroke the temperature of the whole internal *surface* and of the steam is that of the terminal pressure, the steam having really expanded with fresh accessions of heat and of vapor from that part of the cylinder exposed to initial steam; that is, exposed before the cut-off occurs.

Next in the order of events the exhaust opens and the whole interior of the cylinder is exposed to the temperature of the exhaust, the piston and cylinder-head being exposed on an average twice as long as the cylinder walls.

In every engine these changes, whatever they may be, establish an equilibrium among themselves, and the result is that a certain uniform quantity of heat is lost each stroke, provided the thermal value of the steam does not vary.

What is said is merely advanced as a hypothesis, which so far as regards the expansion, receives a probable verification from the curves of the indicator, which approximate to the equilateral hyperbola, more and more nearly as we improve the performance of engines. Dropping the discussion of what befalls steam after the point of cut-off is reached, let us return to initial condensation.

From Mr. Hill's experiments we take the following data:

HARRIS-CORLISS ENGINE.

	Condensing.	Non-condensing.
(1) Stroke s	4·08 ft.	4·08 feet.
(2) Diameter d	1½ ft.	1½ feet.
(3) Volume cylinder V	7·291 c. ft.	7·291 c. ft. Calculated.
(4) True point of cut-off	0·1355	·1491.
(5) Steam from boiler W_a	32063·19 lbs.	32100·25 lbs. In 10 hours.
(6) Its thermal value U	1315·86 B. U.	1255·74 B. U. Experimental.
(7) Thermal value of saturated steam	1214·88 B. U.	1214·74 B. U. From Porter's tables.
(8) For the pressure P_b	90·07 lbs	89·52 lbs. By steam gauge.
(9) Temperature steam T_b	532·8 deg. F	532·4 deg. F. Calculated and table.
(10) Temperature exhaust T_e	145·4 deg. F	212·6 deg. F. Calculated and table.
(11) Specific volume S	257·	258· For initial pressure.
(12) Number of strokes N	151·66	151·62
(13) Pressure at cut-off P_c	86·97	85·91 lbs. By steam gauge.
(14) Specific volume at cut-off	264·	266·5
(15) Steam by diagram W	19335·94 lbs.	20625· lbs. Calculated for point of cut-off, less comp. steam.
(16) Mean eff. pressure P	35·67 lbs.	28·94 lbs.
(17) Max. compression (abs.) B_m	41·07 lbs.	60·57 lbs.
(18) Barometric pres. (abs.)	14·47 lbs.	14·47 lbs.
(19) Ind. horse-power (HP)	165·58	134·29
(20) Clearance k	0·0189	0·0189

(15) is calculated from the following formula:

$$\text{Water in 10 hrs.} = 10 \frac{\left(e - k\frac{B_m}{P_e}\right) \times \text{HP} \times 859375.}{PS} \qquad (9)$$

$$\text{Condensing } 10 \times 165{\cdot}58 \frac{{\cdot}1355 - {\cdot}0076}{35{\cdot}67 \times 264} \times 859375 = 19335{\cdot}94 \text{ lbs.}$$

$$\text{Non-condensing } 10 \times 134{\cdot}29 \frac{{\cdot}1491 - {\cdot}0113}{28{\cdot}94 \times 266{\cdot}5} \times 859375 = 20625 \text{ lbs.}$$

The temperature of the steam is computed from its thermal value. It is much to be regretted that this temperature was not directly observed.

The formula used is

$$\text{Degrees of superheating} = (\text{Observed thermal} - \text{Saturated thermal value}) \times 2 \qquad (10)$$

which when added to the temperature observed by Regnault for saturated steam gives the temperature of the initial steam.

The specific heat being assumed at ·5 with Hirn, rather than ·48 as given for steam by Porter from Regnault.

Comparing the results as to weights of steam.

For Harris-Corliss engine, condensing.

Actual steam from boiler	32063·19
Computed steam at cut-off, less amount of comp.	19335·94
Computed steam at terminal pressure, less amount of comp.	22775·81

giving $r = 1{\cdot}657$ for point of cut-off.

For same engine non-condensing.

Actual steam from boiler	32160·25
Computed steam at cut-off, less amount saved by comp.	20625·00
Computed steam at terminal pressure less comp.	24190·78

giving $r = 1{\cdot}559$ for point of cut-off.

Substituting in formula 8 we have for condensing trial

$$\cdot 657 = \frac{264(387{\cdot}4)}{62\frac{1}{2} \times 151{\cdot}66} C[2{\cdot}667 + 3{\cdot}617]$$

$$C = 0{\cdot}00969 \text{ lbs.}$$

For non-condensing trial

$$\cdot 559 = \frac{266.5 \times 319{\cdot}8}{62\frac{1}{2} \times 151{\cdot}62} C[2{\cdot}667 + 3{\cdot}289]$$

$$C = 0{\cdot}01044 \text{ lbs.}$$

$$\text{Difference} = 0{\cdot}00075 \text{ lbs.}$$

That is, we might infer from the above induction that the condensation of a plate of cast iron one foot square rapidly subjected to varying temperatures is about $\frac{1}{100}$ of a pound per minute and per degree Fahrenheit. It must not be forgotten that our premises are not very accurate.

Having thus determined a value of $C = \frac{1}{100}$ lbs., we can discuss the point of cut-off.

Actual steam $= r$ times indicated steam. For one stroke

$$\frac{\text{Work}}{\text{Cost of work in steam}} = y = \frac{PV}{r\,\frac{62\frac{1}{2}}{S}\,eV} \tag{11}$$

Clearance and compression being neglected.

Substituting the value of r from equation (8) we would have

$$y = \frac{P}{\frac{62\frac{1}{2}}{S}\,e + \frac{T_b - T_a}{100\,N}\left[\frac{4e}{d} + \frac{2}{s}\right]} \tag{12}$$

and letting

$$A = \frac{62\frac{1}{2}}{S} \tag{13}$$

$$D = \frac{T_b - T_a}{100\,N} \tag{14}$$

We have for a maximum value of equation (12).

$$e = \frac{B}{P_b} + \frac{2Dd}{s(Ad + 4D)}\ \text{nat. log.}\ \frac{1}{e} \tag{15}$$

If in this we substitute the values for the Harris-Corliss Engine condensing we obtain

$$A = \frac{62{\cdot}5}{257} = 0{\cdot}243 \qquad D = \frac{387{\cdot}4}{100 \times 150} = {\cdot}0258$$

$$e = \frac{3{\cdot}35}{104{\cdot}55} + \frac{2 \times {\cdot}0258 \times 1{\cdot}5}{4({\cdot}243 \times 1{\cdot}5 + 4 \times {\cdot}0258)}\ \text{nat. log.}\ \frac{1}{e}$$

$$e = {\cdot}032 + {\cdot}0414\ \text{nat. log.}\ \frac{1}{e}$$

If in this equation of condition we assume $e = \frac{1}{8} = 0{\cdot}125$ for a first trial we have ${\cdot}125 = 0{\cdot}032 + {\cdot}0858 = 0{\cdot}118$.

Assume $e = \frac{1}{9} = {\cdot}111$ for a second trial we have

$${\cdot}111 = 0{\cdot}032 + {\cdot}0906 = 0{\cdot}122.$$

We see, therefore, that the Harris-Corliss engine condensing might have cut off at about $\frac{1}{8}$ or a little over, but not as high as $\frac{1}{6}$, with the greatest actual economy of steam per *indicated* horse-power. It was possibly doing its best per net horse-power clear of the engine friction as it was run (0·1355 cut-off.)

These limitations are also derived by other methods in this JOURNAL, August, 1880, and December, 1883; also in "The Relative Proportions of the Steam Engine," Chap. xvi., at somewhat greater length than elsewhere.

If now we take up the same engine non-condensing we have

$$A = 0{\cdot}243 \text{ and } D = \frac{319{\cdot}8}{100 \times 150} = {\cdot}0213$$

$$e = \frac{14{\cdot}89}{104.} + {\cdot}081 \text{ com. log. } \frac{1}{e}$$

$$e = 0{\cdot}143 + {\cdot}081 \text{ com. log. } \frac{1}{e}$$

If in this equation of condition we assume

$$e = \tfrac{1}{5} = {\cdot}20 \text{ we have } {\cdot}20 = {\cdot}143 + {\cdot}057 = {\cdot}20.$$

That is to say, the Harris-Corliss engine non-condensing was probably run so as not to produce its best actual economy of steam as its cut-off was ·15 of the volume and therefore too early, not for economy of indicated steam, but for economy of actual steam from boiler.

A laborious calculation of the amount of steam re-evaporated in the steam cylinders at various points from the point of cut off to exhaust opening has led the writer to believe that Mr. Hill's surmise as to excessive leakage in the case of this engine is incorrect, when the engine was in motion and thoroughly warmed up.

The large percentage of initial steam condensed in the case of the non-condensing trial was caused, perhaps, by a too early cut-off. The Harris-Corliss engine has been selected because the diagrams given for that engine would appear to show least probability of a leak past the piston and because Mr. Hill remarks, "Mr. Ellis, of the Harris engine attempted to hasten the seating of the steam valves of his engine by filing previous to the trials with good results as shown by the diagrams. No effort was made with either the Reynolds or Wheelock engines to seat the valves except by wear."

Taking the case of a pair of diagrams from Buckeye engine with Korting Jet Condenser, we have the following data:

Stroke, $s = 44$ inches $= 3{\cdot}667$ feet.
Clearance, $k = {\cdot}02s = {\cdot}07334$ feet.
Diameter, $d = 22$ inches $= 1{\cdot}833$ feet.
Abs. initial pressure, $P_b = 92{\cdot}7$ pounds per square inch.
Abs. back pressure, $B = 4{\cdot}7$ pounds per square inch.
Number of strokes, $N = 140$ per minute.
Temperature of initial steam, $T_b = 322{\cdot}14$ deg. Fahr.
Temperature of exhaust steam, $T_e = 159{\cdot}55$ deg. Fahr.
Specific volume, initial steam, $S = 286{\cdot}9$.

$$D = \frac{T_b - T_e}{100N} = \frac{162{\cdot}59}{14000} = 0{\cdot}0116 \qquad A = \frac{62\frac{1}{2}}{S} = \frac{62{\cdot}5}{287} = 0{\cdot}218$$

$$e = \frac{4{\cdot}7}{92{\cdot}7} + \frac{2 \times {\cdot}0116 \times 1{\cdot}833 \times 2{\cdot}3026}{3{\cdot}667[0{\cdot}218 \times 1{\cdot}833 + 4 \times {\cdot}0116]} \text{ com. log. } \frac{1}{e}$$

$$e = {\cdot}0507 + 0{\cdot}060 \text{ com. log. } \frac{1}{e}$$

In this equation of condition assume $e = \frac{1}{8} = {\cdot}125$.
We have

$$0{\cdot}125 = {\cdot}0507 + {\cdot}054 = {\cdot}105.$$

$$\text{For } e = \tfrac{1}{9}\ 0{\cdot}111 = {\cdot}0507 + {\cdot}0572 = {\cdot}108.$$

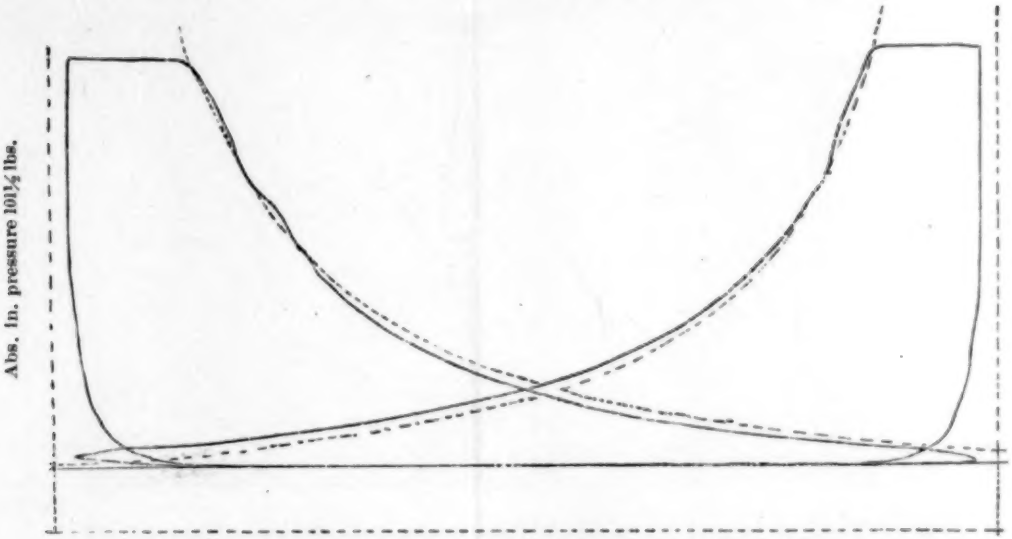
That is, it would appear as if the greatest actual economy per indicated horse-power would have been reached assuming the steam to be saturated and neglecting the clearance and compression with a cut-off of nearly $\frac{1}{10}$ the volume. The actual cut-off of the diagram would appear to be very closely $\frac{1}{8}$ of the cylinder volume.

All engineers are agreed upon the point that the presence of clearance causes loss.

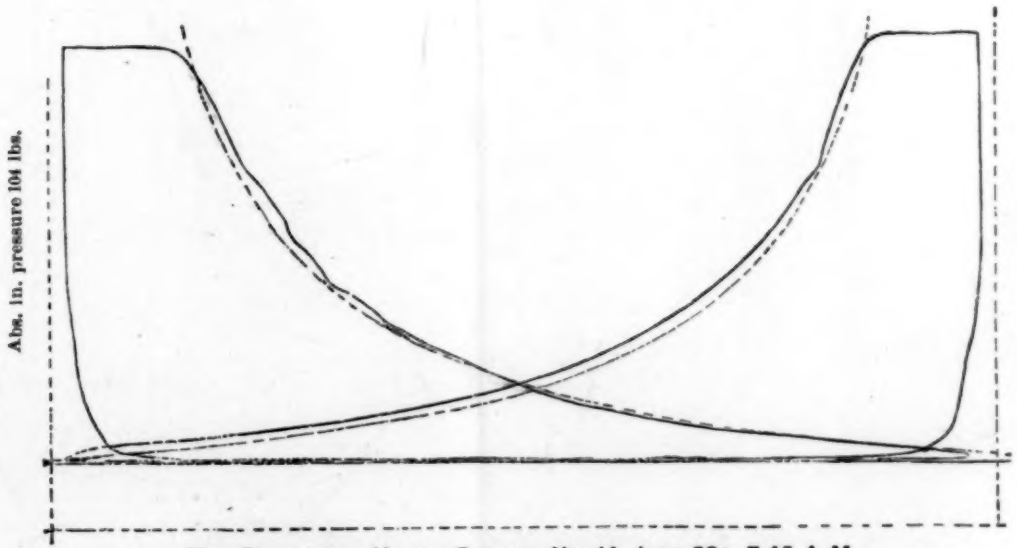
Compression, too, must cause some small loss of efficiency of steam, as well as a loss of power in the engine.

However, we cannot avoid clearance entirely, it being doubtful if mechanical considerations will permit us to get much below the 2 per cent. clearance already attained, and therefore we must correct the one evil by the other so far as possible.

Does it not seem possible, too, since the specific heat of steam under constant pressure is but one-half that of water, that superheating steam will not diminish initial condensation directly in proportion to the



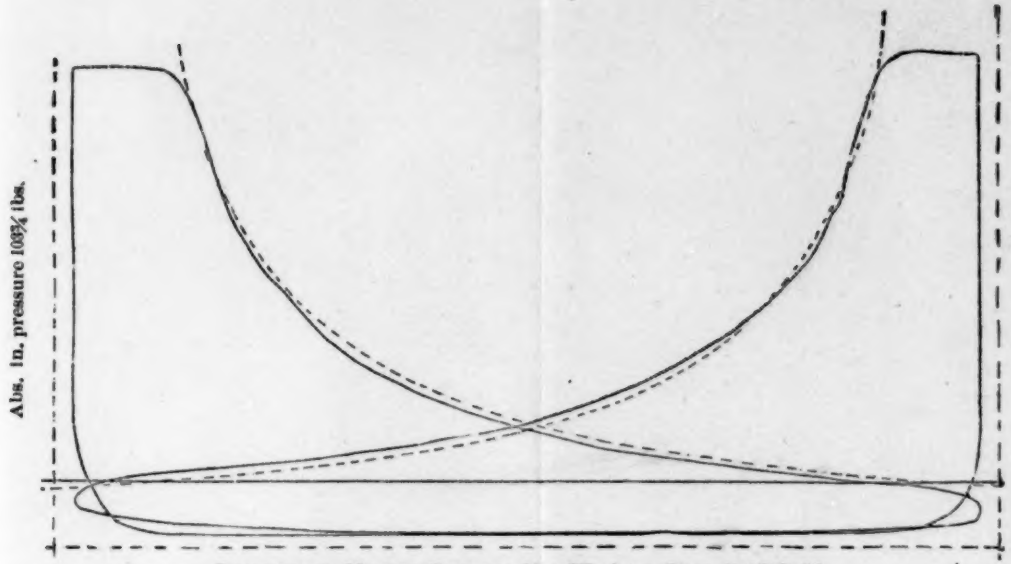
NON-CONDENSING HARRIS-CORLISS, NO. 28, JUNE 22D, 11.15 A. M.—THOMPSON INDICATOR.
The broken curve is an equilateral hyperbola from the point of cut off in each case of Harris-Corliss Engine.



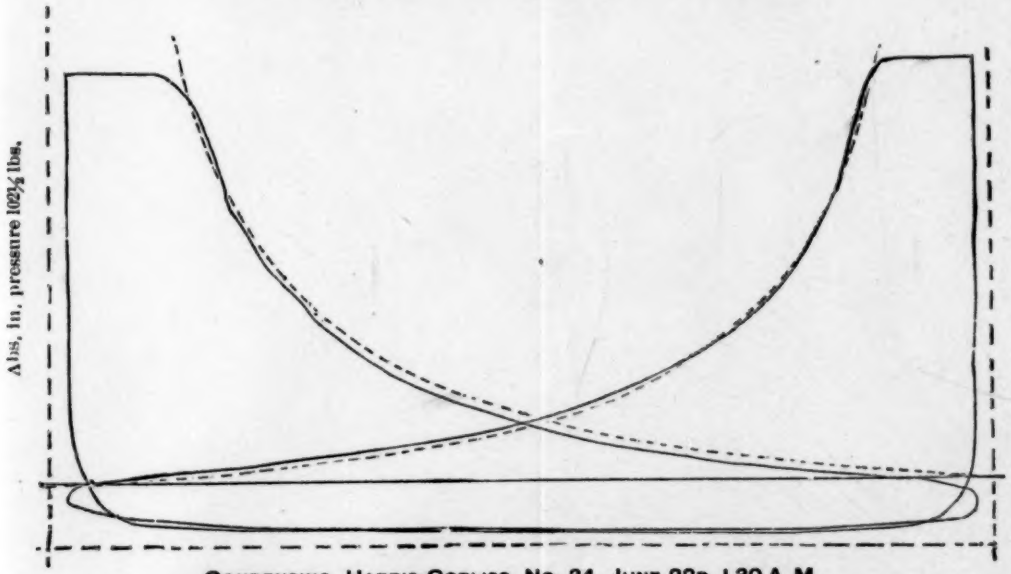
NON-CONDENSING HARRIS-CORLISS, NO. 14, JUNE 22D, 7.45 A. M.

The above diagrams of the Harris-Corliss Engine are photo-engraved reproductions from M
given with each diagram as a scale.

The diagrams of the Buckeye Engine and the Brown Engine have been engraved from ten



CONDENSING HARRIS-CORLISS, NO. 27, JUNE 21ST, 11.45 P. M.



CONDENSING HARRIS-CORLISS, NO. 34, JUNE 22D, 1.30 A. M.

DIAGRAM OF BUC
The solid curve above is the Adiabatic
diagra

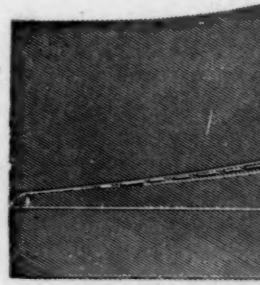
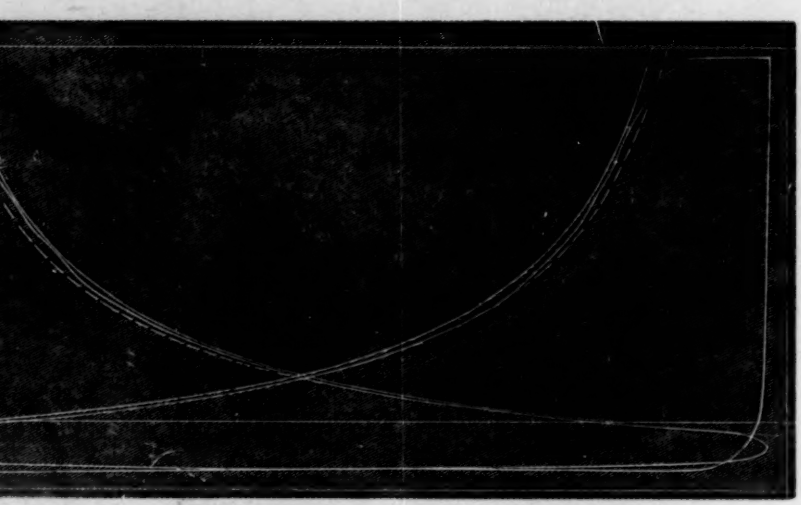
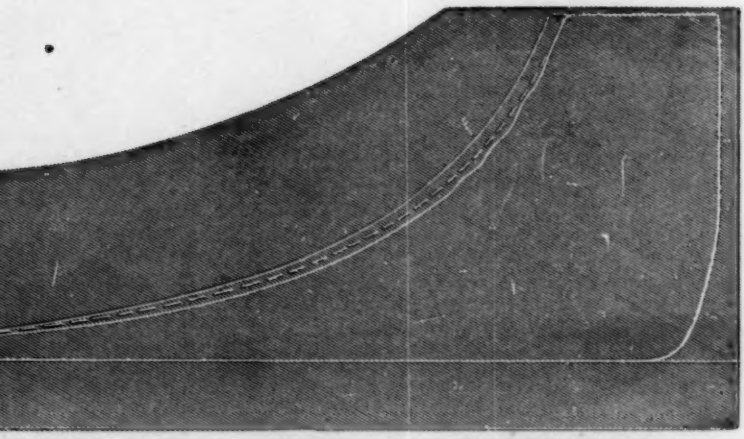


DIAGRAM OF THE B

t Hill's diagrams, and are as nearly fac-similes of the originals as possible. However, as the errors of reproduction are in proportion, the diagr
plates carefully made for Mr. Thompson from the original diagrams, and may be relied upon as being practically accurate.



M OF BUCKEYE AUTOMATIC ENGINE. KORTING JET CONDENSER.
the Adiabatic Curve, and the broken curve below is the Isothermal Expansion Curve, traced on the diagram for comparison, and beginning at the toe of the diagram.
SCALE, 40 lbs.



OF THE BROWN ENGINE. NON-CONDENSING. TAKEN BY F. W. BACON.
SCALE, 40 lbs.

, the diagrams can be reworked by using the ABSOLUTE INITIAL PRESSURE

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number of degrees of superheating, but rather in proportion to half the degrees of superheating? In other words, is it not more probable that T_b should be made equal to the temperature of saturated steam of the given pressure plus the number of British units by which its thermal value is less than that of the superheated steam under consideration? If we consider the properties of iron alone, is it not possible that superheating may increase the amounts of initial condensation?

The fact of initial condensation in large quantity must influence subsequent expansion, because we have not only a surface of hot iron, hotter than the steam the moment it begins to expand, but also on this surface a film of water ready to vaporize the instant the pressure upon it is relieved, and thus to augment the volume of the expanding steam. When steam is not dry as taken from the boiler, it is easy to see that the volume and pressure of the steam may be so much augmented as to raise the expansion line above a true hyperbola.

The temperature of the steam and cylinder surface falls during expansion, but still a film of water at this lower temperature remains upon it, and instantly at the opening of the exhaust vaporizes, drawing its heat from the cylinder's surface, cooling the piston and cylinder head to the greatest depth, because they are the longest exposed, the result being increased initial condensation, and making the time of exposure to exhaust $\frac{1}{N}$ the controlling element rather than the time of exposure to initial steam $\frac{e}{N}$.

If in equation (8) we substitute the value of T_b under the above assumption we have

For the Harris Corliss engine condensing $C = 0{\cdot}01306$
" " " non-condensing $C = 0{\cdot}01518$

Difference..... 0·00212

It would not appear from this that these assumptions are as correct as the preceding, which give results differing by 0·00075 pounds of steam per minute per square foot of surface raised one degree Fahr.

It is worthy of note that the superheated steam in the Harris Corliss engine must have instantly become very wet steam upon its admission to the cylinder, and therefore if damage is done by superheated steam, its evil effects will appear upon the valve motion and upon lubricants fed through the steam pipe.

It would seem as if especial care given to the jacketing of the cylinder barrel would be useless trouble until we have suppressed initial condensation *due mainly to the piston and cylinder heads.*

Even were we to obtain very good non-conducting surfaces for these latter parts, it is doubtful if a film of water would not appear on them and demand conversion into steam at the beginning of each stroke.

Taking next the case of a Brown engine, non-condensing, steam-jacketed, data as follows:

Stroke, $s = 42$ inches $= 3{\cdot}5$ feet.
Clearance, $= {\cdot}02s = {\cdot}07$ feet.
Diameter, $d = 16$ inches $= 1{\cdot}333$ feet.
Abs. initial pressure, $P_b = 88{\cdot}7$ pounds per square inch.
Abs. back pressure, $B = 18$ pounds per square inch.
Number of strokes, $N = 120$ per minute.
Temperature of initial steam, $T_b = 319{\cdot}01$ deg. Fahr.
Temperature of exhaust steam, $T_e = 222{\cdot}38$ deg. Fahr.
Specific volume of steam, $S = 301{\cdot}02$.

Steam wet. Substituting in formulæ (13), (14) and (15)

$$D = \frac{96{\cdot}63}{12{,}000} = {\cdot}00805 \qquad A = \frac{62{\cdot}5}{301{\cdot}02} = 0{\cdot}207$$

$$e = \frac{18}{88{\cdot}7} + \frac{2 \times {\cdot}00805 \times 1{\cdot}333 \times 2{\cdot}3026}{3{\cdot}5\,[{\cdot}207 \times 1{\cdot}333 + 4 \times {\cdot}00805]} \text{ com. log. } \frac{1}{e}$$

$$e = 0{\cdot}203 + {\cdot}046 \text{ com. log. } \frac{1}{e}.$$

Assume $e = \frac{1}{4} = {\cdot}25 = {\cdot}203 + {\cdot}027 = {\cdot}23$, or very nearly the same as assumed.

In the diagram the steam would seem to be cut off at about $\frac{1}{5}$ of the cylinder volume.

It would seem, when we use superheated steam, as if the condensation on the interior of the cylinder should be less than when saturated steam is used, but this is dependent upon the action of the steam.

If the steam condenses only as it comes in contact with the walls, that is, condenses as a piece of ice melts, on the outside, the main body of the steam *will remain superheated*, and successive layers of steam on the outside be condensed until the walls are of the same temperature as its temperature of saturation, after which the superheated steam would strive to re-evaporate the condensation, and the iron to keep it condensed and add more to it, with all the advantage on the side of the iron. Since, if we assume steam of an average specific volume of

300, their comparative weights, volume for volume, are—iron 2,160, steam 1, and as the specific heat of steam is 0·48 and that of iron 0·12, we see that, volume for volume or layer for layer, iron will take 540 times as much heat as steam. So we see the iron will not only keep what it has condensed, but will add more to it by conducting the heat from the film of water upon it away so rapidly as to cause additional condensation in the adjacent layers of steam, which have comparatively no conducting power at all, if we can draw any inference from the ease with which priming occurs in it, and the suspension of globules of water during expansion of steam.

The advantages of superheated steam will be found to be in the more complete re-evaporation during expansion leaving a drier cylinder and consequently less to be evaporated by the heat of the cylinder during the exhaust, which will therefore be cooled to a lesser depth.

It is not surmised that the temperature of the iron of the steam cylinder rises above the temperature of saturated steam of the initial pressure, but the probability is suggested that the iron gets *more* heat in proportion to the superheating, and therefore re-evaporates the steam more readily and thoroughly. Certainly it would not appear, in the case of the Harris-Corliss engine condensing, that 66 per cent. of the indicated steam should be condensed at cut-off, or with the same engine non-condensing 56 per cent. of the indicated steam should have been condensed at cut-off, if all the superheating of the initial steam had vanished before condensation began.

Neither does it appear from the diagrams that the superheating had the effect of raising the expansion curve above an equilateral hyperbola in the Harris engine, nor does wet steam seem greatly to modify the expansion curve of the Brown engine.

It does not seem probable, however, that an engine using super-heated steam, as did the Harris, should most economically cut off later than the Buckeye engine, assumed to use saturated steam, yet this would appear to be the case from the formulæ used and may really be the case, because of the greater specific volume of superheated steam. It has already been shown that even if all the steam used appeared in the diagram no great economy would result from a cut-off earlier than $\frac{1}{8}$ stroke.

The fact, however, is undeniable that the amount of heat conducted away is proportional to the conductivity and heat capacity of the iron cylinder, and we are told that this conductivity is directly proportional to the difference of temperatures.

(To be concluded.)

AN INVESTIGATION LOCATING THE STRONGEST OF THE BRONZES.

By W. Ernest H. Jobbins, M. E.

(Continued from page 103.)

The research was now restricted to the examination of alloys lying nearer the point copper = 100, *i. e.*, the upper vertex of the triangle, as seen in the figure, and all such alloys were tested by tension, compression, torsion and transverse stress. The results are quite accordant, and the quality of the metal could be judged as well by one set of data as another, although, as a matter of course, the strain-diagram, obtained automatically, gave the best idea of the nature of the metal where the observer had been accustomed to that method of

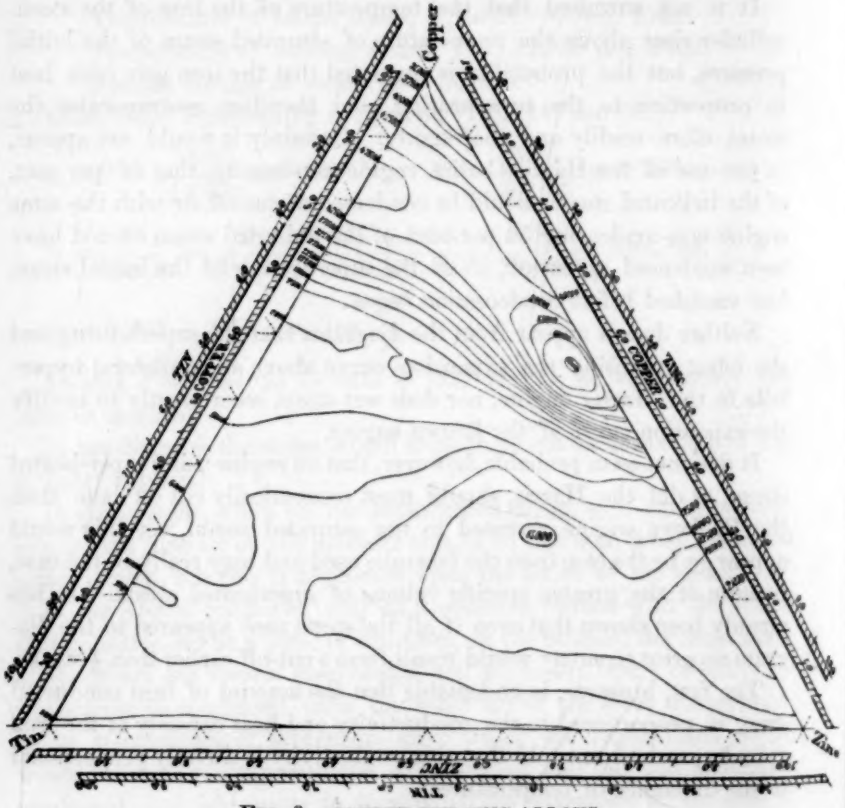

Fig. 3.—COPPER-TIN-ZINC ALLOYS.

research. When the figures thus obtained had been entered in the triangular map, lines of equal strength, of equal ductility, or of equal resistance, could be drawn, as, in topographical work, lines of equal altitude are drawn, and the map becomes thus a useful representative of the valuable qualities of all possible alloys. Fig. 3 represents such a map of all copper-zinc-tin alloys. The scale of altitude is obtained by considering the relation of tension to torsion resistance, which is nearly 25,000 pounds per square inch (1,758 kilogrammes per square centimetre) for each 100 foot-pounds (13·82 kilogrammetres) of torsional moment for the standard test-specimen, which specimen was turned to a standard gauge, and made $\frac{5}{8}$ inch (1·84 centimetres) diameter and 1 inch (2·54 centimetres) long in the cylindrical part exposed to strain. These facts, as determined experimentally, were subsequently still better exhibited by another method devised by Prof. Thurston for class illustration, thus: Upon a triangular base of metal, laid off as above, erect a light metallic staff, by drilling a hole for its support at each point laid down, as representative of an alloy tested; make the altitude of each of these wires proportional to the strength of that alloy. There is thus produced a forest of wires, the tops of which are at elevations above the base-plane proportional to the strength of the alloys studied. Similar constructions may be made to represent the elasticity, the ductility, or any other property of these alloys. Next, fill in between these verticals with clay, or, better, with plaster, and carefully mould it until the tops of all the wires are just visible, shining points in the now smooth surface of the model. The surface thus formed will have a topography characteristic of the alloys examined, and its undulations will represent the characteristic variations of quality, with changing proportions of the three constituents. This was made for Prof. Thurston, and was cast in the alloy which is the subject of this paper, the plaster cast made as above being used as a pattern, and this cast is used in lecture-room illustrations, and is supplied to other institutions.

Fig. 4 is a good representation made from a photograph of the model for the American Association for the Advancement of Science. The alloys studied were originally intended to furnish data during a preliminary research that should serve as a guide in a later and more complete study of this important and intensely interesting field of investigation; these alloys were purposely made precisely as the brass founder is accustomed to make them. The data obtained were conse-

quently exceedingly variable, and the results of this work indicated as one, and not the least valuable of deductions from it, that the same alloy, and especially where the proportion of copper is great, may give very different figures when tested, according as it is more or less affected by the many circumstances that influence the value of all brass foundry products. But, allowing for all such minor variations, it is evident at a glance that the alloys of maximum strength are grouped, as shown in Figs. 3 and 4, about a point not far from copper = 55, zinc

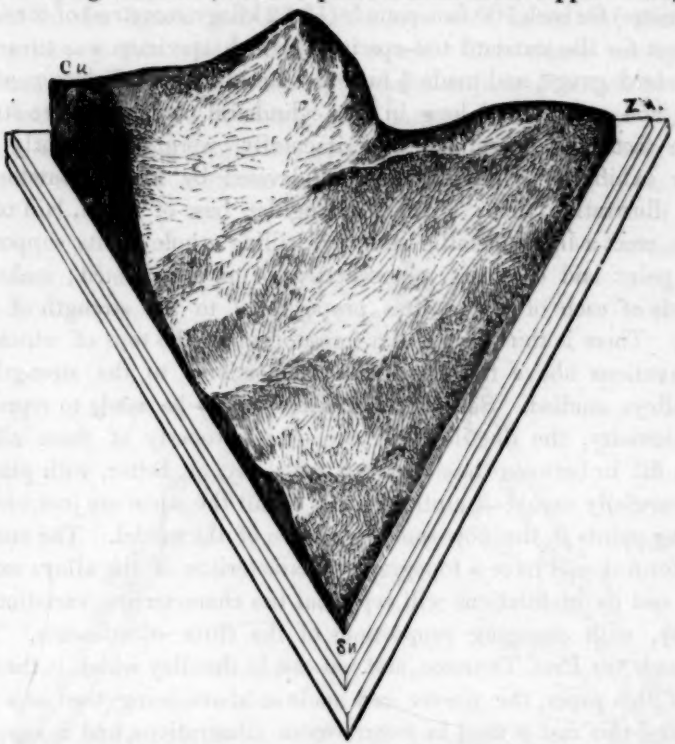

FIG. 4.—MODEL OF STRENGTH OF ALLOYS.

= 43, and tin = 2. This point is encircled in the map, Fig. 3, by the line marked 65,000 pounds per square inch (4,570 kilogrammes per square centimetre) tenacity, and is represented on the model, Fig. 4, by the peak of the mountain seen at the farthest side—the copper-zinc side as shown. This is obviously the strongest of all bronzes, and an alloy of this composition, if exactly proportioned, well melted, perfectly fluxed, and so formed as to produce sound and pure metallic

alloys, with such prompt cooling as shall prevent liquation, is the strongest bronze that man can make.

Prof. Thurston finally made this alloy, and of it constructed the model represented in the last figure. It is a close-grained alloy, of rich color, fine surface, and takes a good polish. It oxidizes with difficulty, and the surface then takes on a pleasant shade of statuary bronze green. Testing it, it was found to have considerable hardness, but moderate ductility, though tough and ductile enough for most purposes; it would forge if handled skillfully and carefully, and not too long or too highly heated; had immense strength, and seemed unusually well adapted for general use as a working quality of bronze. In composition, however, it is seen to be a brass, with a small dose of tin. The alloy made as representing the alloy for purposes demanding toughness as well as strength contains less tin than the above composition, Cu 55, Sn 0·5, Zn 44·5. It had a tenacity of 68,900 pounds per square inch (4,841 kilogrammes per square centimetre) of original section, and 92,136 pounds (6,477 kilogrammes) on fractured area, and elongated 47 to 51 per cent., with a reduction to from 0·69 to 0·73 per cent. of its original diameter. No exaltation of the normal elastic limit was observed during tests made for the purpose of measuring it if noted. This alloy was wonderfully homogeneous, two tests by tension giving exactly the same figures, 68,900. The fractured surface was in color pinkish-yellow, and was dotted with minute crystals of alloy produced by cooling too slowly. The shavings produced by the turning tool were curled closely, like those of good iron, and were tough and strong. This alloy and the "Tobin Alloy," Cu 58·22, Sn 2·30, Zn 39·48, are good working metals, the latter being capable of great improvement by skillful working either hot or cold, and thus of obtaining a tenacity of over 100,000 pounds per square inch (7,311 kilogrammes per square centimetre).

Following the inequalities exhibited by the map, we notice the fact that the line of maximum elevation crosses the field from about Cu 50, Zn 50 to Cu 85, Sn 15, is included in a band bounded by the formulas $M = Z + 4t = 50$, and $M = Z + 3t = 55$, in which Z is the percentage of zinc present in any triple alloy of that series, and T is the percentage of tin. It has been stated that along this maximum line the tenacities of the alloys should be at least $T_m = 40{,}000 + 500\,z$ in pounds on the square inch, or $T_m{}^k = 2{,}812 + 35{\cdot}15\,z$ in kilogrammes on the square centimetre. Thus, taking the last line,

which contains the strongest but least ductile compositions, we find the following tenacities: The alloy $Z = 1$, $T = 18$ will also contain Cu $= 100 - 19 = 81$, and this alloy, Cu 81, Zn 1, Sn 18, should have a tenacity of at least $T_m = 40{,}000 + (500 \times 1) = 40{,}500$ pounds per square inch; $T_m^1 = 2{,}812 + (35{\cdot}15 \times 1) = 2{,}847$ kilogrammes per square centimetre. The alloy Cu 60, Zn 5, Sn 16 should have at least the strength $T_m = 40{,}000 + (500 \times 5) = 42{,}500$ pounds per square inch; $T_m^1 = 2{,}812 + (35{\cdot}15 \times 5) = 2{,}988$ kilogrammes per square centimetre, etc. These are rough working formulas, that, while often departed from in fact, and, while purely empirical, may prove of real value in framing specifications. Where the composition is that of brass rather than bronze this line of alloys exhibits more toughness. The alloys Cu 55, Sn 2, Zn 43, and Cu 55, Sn 0·5, Zn 44·5 were quite excellent in this respect. Tin reduces ductility more rapidly than does zinc.

Prof. Thurston deduces the following equations, $T = 30{,}000 + 1{,}000\ t + 500\ z$ and $T^1 = 2{,}109 + 70{\cdot}3\ t + 35{\cdot}15\ z$, which he says cover the whole field of copper-tin-zinc alloys useful to the engineer, *i. e.* in which $4\ t + 2 < 50$. But it must be understood that this approximate statement of tenacities is a minimum for well made alloys, and is also applicable only to those containing a larger percentage of copper than to those which lie along the maximum line; the alloys to which they apply are, however, the best alloys for general use. The ductility of these alloys is a subject of quite as much interest to the engineer as their strength, and in this quality the triple alloys are as variable as any other. There is a territory which is valueless as far as ductility is concerned, and it is bounded by a slightly curved line, to which a line having the equation $2{\cdot}5\ t + z = 55$ is nearly tangent. The alloys lying along this line have nearly equal ductility, extending, according to the measurements obtained by the autographic machine, about ·03 per cent. Above this line is another having nearly the equation $4\ t + z = 50$, which last line is that of equal ductility for alloys exhibiting extensions on the strain-diagram of 3 per cent. Still nearer the pure copper corner fairly representing alloys containing about $3\frac{3}{4}\ t + z = 48$, and along which the extensions as per strain-diagrams were 7·3 per cent., and another such line extending from the standard gun metal compositions on the one side to the tough Muntz metal on the other—Cu 90, Sn 10, to Cu 55, Zn 45—of which the equation is nearly $4{\cdot}5\ t + z = 45$—represents and identifies alloys averaging, as cast during this initial

research, an extension of 17 per cent. These lines are best seen on the sheet of extension, Fig. 5. All alloys lying above the line taken here as a boundary line give figures for tenacity that are usually considered good; they all exceed 30,000 pounds per square inch (2,109 kilogrammes per square centimetre).

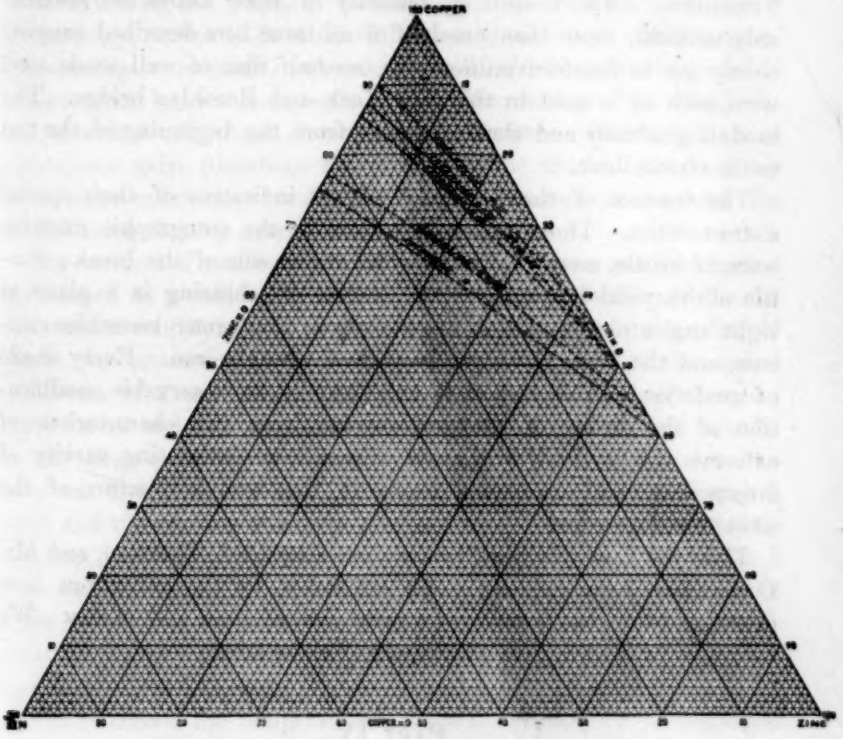

FIG. 5.—DUCTILITY OF COPPER-TIN-ZINC ALLOYS.

It is seen that the addition ot tin and of zinc to cast copper increases the tenacity, at least up to a limit marked by the line $3t + z = 55$, and that the influence of tin is nearly twice as great as that of zinc, while the limit of useful effect is not reached in the latter case until the amount added becomes very much greater than with the former class, the copper-tin alloys. Brasses can be obtained which are stronger than any bronzes, and the ductility of the working compositions of the former class generally greatly exceeds that of the latter. So sensitive is zinc to the presence of tin that M. Bischof states that he can detect the addition of one part of tin in

ten millions of pure zinc. The range of useful introduction of tin is very much more restricted than with zinc; alloys containing 12 to 15 per cent. tin are so hard and brittle as to but rarely find application in the arts, while brass, containing 40 per cent. zinc, is about the toughest and most generally useful of all the copper-zinc "mixtures." The moduli of elasticity of these alloys are remarkably uniform, more than one-half of all those here described ranging closely up to fourteen millions, or one-half that of well made steel wire, such as is used in the New York and Brooklyn bridge. The moduli gradually and slowly increase from the beginning of the test to the elastic limit.

The fracture of these alloys is always indicative of their special characteristics. Those broken by torsion in the autographic machine were, if brittle, more or less conoidal at one side of the break; ductile alloys yield in similar circumstances by shearing in a plane at right angles to the axis of the test piece; the former resembles cast-iron, and the latter have the fracture of wrought-iron. Every shade of gradation in this respect is exhibited by an observable modification of the surface of fracture, varying from that characteristic of extreme rigidity and brittleness, through an interesting variety of intermediate and compound forms, to that seen in fracture of the most ductile metals.

Thus the field has been reconnoitered by Prof. Thurston, and Mr. Coster has been guided in his researches by the indications here given, and thus has been saved a great deal of time and money We may now proceed to give an abstract of these labors.

Part IV.

The Strongest Bronze.

Prof. Thurston having laid down the boundaries within which the useful alloys of copper-tin-zinc are to be found, Mr. Maurice I. Coster, M.E., under his direction and supervision, carefully investigated the enclosed field and embodied the results of his labors in a paper of which the following is an abstract. Mr. Coster began his work by forming two series in order to fix more accurately this particular part of the field. When its boundaries were approximately defined, three other series were proposed, in which the alloys were made to differ by smaller percentages.

The copper employed in these investigations was the best Lake Superior metal; the tin was the best Banca, and the zinc the best Lehigh which could be procured in the market. The total amount of metal weighed out for each bar was 4·5 kilogrammes for every series except the second, in which it was 1,500 grammes. The weighings were made in the Physical Laboratory of the Stevens Institute of Technology, on the U. S. standard balance to within 10 milligrammes. The castings were made in a vertical iron mould 28 inches long and of 1 square inch internal cross-section. The inner surface of the mould was coated with a mixture of charcoal dust and water. In the third and subsequent series, plumbago was substituted for charcoal dust, and this gave more satisfactory results, the friction between the bar and the mould being thereby nearly eliminated.

The method of casting was as follows: The copper was first melted and raised to a sufficiently high temperature to allow the addition of tin without solidifying. The zinc, after being wrapped in a piece of paper, was introduced in the molten metal and kept below the surface by means of a pair of tongs, thus preventing its coming in contact with the air and its consequent volatilization. Charcoal dust in sufficiently large quantities was thrown into the crucible and thus oxidation was almost prevented. The metal was then well stirred with a stick and the crucible taken out of the furnace. A few minutes before pouring, the tin was added and the alloy well agitated to cause a thorough mixture of the metals. The dross having been removed from the surface, the metal was then poured into the mould—immediately after the temperature test, to be described presently, was made—and then allowed to cool. It was deemed advisable to determine for future reference the temperatures at which the alloys were cast, since this is supposed to have some influence upon their strength and other qualities. The method employed was the same as that used by Messrs. Levi and Kunzel in their experiments on "phosphor bronze." As soon as the casting was taken out of the mould the series number was marked on it in black paint and the top and bottom parts were designated by the letters A and B respectively. This distinction was made to enable the observer to determine the difference in properties of various portions of the bar, and also to assist him in detecting the extent of the liquation which took place in some of the castings.

The first test to which the bars were subjected was by transverse stress; after this, the remaining portions of the bars were turned in a

lathe for tensile specimens. From the results of the transverse and tensile tests, curves were constructed whose ordinates represent the loads and the abscissas the corresponding deflections and elongations. By comparing these curves the general properties of the alloys can be studied, and the experienced eye can tell at a glance if the metal represented by a curve will answer the purposes for which it is intended to be used. The fractures having been described, after the test pieces were broken they were turned into specimens to be tested by torsion. Pieces of about one inch in length were cut off the cylindrical part of the broken tensile specimens for use in the determination of specific gravity. They were cut off near the middle of the bar and as far from the fractured ends as was possible, in order to obtain the portions which were the least disturbed. The torsion specimens were made one and three-eighths inches at the ends and one inch between the shoulders and five-eighths diameter; thus,

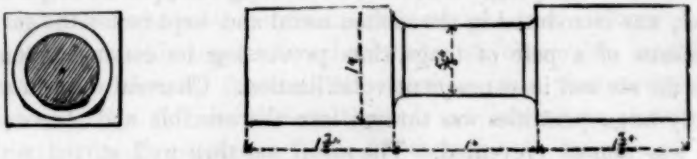

FIG. 6.—TEST-PIECE.

Some of the very brittle alloys could only be turned to a cylinder of about one inch in diameter, while others could not be turned at all. These were then ground to a cylindrical form on an emery wheel. In calculating the results it was assumed that the torsional moments and resiliences vary directly as the cubes of the diameters of the test-pieces, and the figures obtained were reduced in this manner that they might be compared with those of the standard diameter. The machine used for the torsion tests was Prof. R. H. Thurston's Autographic Recording Testing Machine, (Fig. 7.) It consists of two strong wrenches carried by frames and which depend from axes in the same line, but not connected with each other. To one of the wrenches is fixed an arm which carries a weight at the lower end. Motion is given to the other wrench by means of a worm and gear. Two centres are placed in the axis of the machine and project into the recesses of the wrenches; one of them is fixed, while the other is movable and has a spring pressing behind it. The specimen to be tested is placed between the centres and fastened to the wrenches by a set of steel wedges. Its axis is thus

made to coincide with that of the machine, a result which could not always be attained with the steel chucks formerly used. A guide curve is secured to one of the frames, and is of such a form that its ordinates are proportional to the torsional moments exerted by the weighted arm, while moving up the arc, to which the corresponding abscissas of the curve are proportional. A pencil-holder is carried

FIG. 7.—AUTOGRAPHIC TESTING MACHINE OF PROF. THURSTON.

on this arm and the pencil is pushed forward by the guide-curve as the arm is forced out of the vertical position. The movement of the pencil is thus made proportional to the force which, transmitted through the test-piece, produces deflection of the weighted arm. The other wrench carries a cylinder, upon which the paper receiving the record is clamped, and the pencil makes its mark on the table thus provided. This table having a motion relatively to the pencil, which is precisely the relative angular motion of the two extremities of the tested specimen, the curve described upon the paper is always of such a form that the ordinate of any point measures the amount of the distorting force at a certain instant, while its abscissa measures the distortion produced at the same instant. The diagrams obtained by this machine, when interpreted, will give relative measures of the strength, ductility, and resilience of the materials, and will also

indicate their degree of homogeneity. Some of the alloys of the first and second series were so weak that no curves indicating their properties could be obtained if they were tested with the large weight attached to the machine. A weight of 30 pounds was then substituted and in several cases no auxiliary weight was used, the weight of the arm alone being sufficient to break the specimen.

All broken specimens were carefully stored in trays made especially for this purpose, and can be referred to at any time. The turnings of the tensile pieces were all preserved in packages and laid aside for chemical analysis, The outside and inside turnings of the tension-pieces were preserved separately for analysis, in case it should be desired to determine the difference in composition near the surface and near the centre for those alloys where lateral liquation had taken place.

In order to ascertain what results would be obtained by casting together brass and bronze of known properties, the first series of triple alloys was prepared in proportions based upon results obtained in Prof. Thurston's work as the strongest, weakest, most and least resilient of alloys; and by various combinations of these, twelve alloys (including "Tobin's alloy") were obtained. As the writer confined himself in his own labors to the results obtained by the Autographic Recording Machine, we will omit the statement of results obtained in the transverse and tensile tests, fully described by Mr. Coster in his paper, and pass to those results which he obtained from the torsion tests, which were strictly concordant with and more instructive than the former.

1st Series.—The areas of the autographic strain-diagrams were computed with an Amsler planimeter, and the resilience from the data thus found. No. 5 (Cu. 88·135, Sn. 1·865, Zn. 10), was made up of the most resilient bronze and brass, and its resilience was less than that of either of its components. No. 6 (Cu. 45, Sn. 23·75, Zn. 31·25) composed of the least resilient bronze and brass, was less resilient than the brass, but more so than the bronze. No. 7 (Cu. 66·885, Sn. 1·865, Zn. 31·2), formed of the most resilient bronze and the least resilient brass, was much less resilient than the bronze, but considerably more so than the brass. No. 8 (Cu, 66·25, Sn. 23·75, Zn. 10), was made of the least resilient bronze and the most resilient brass. It was less resilient than either the bronze or the brass. No. 4 was so brittle that it was not tested at all. The greatest resistance to tor-

sion of all the bars of the series was exhibited by No. 7, and the mean of its torsional moments exceeded that of all the others. It was of a more homogeneous structure, and may be considered the best alloy of the series. No. 4 was the most brittle of the series, and also the least resilient. No. 5 was the most ductile and the most resilient. No. 12 (Cu. 58·22, Sn. 2·30, Zn. 39·48) was shown by all the tests to be the strongest alloy tested in the Mechanical Laboratory. It exceeded good wrought iron in strength, and was sufficiently resilient to resist shocks. Its modulus of elasticity, as calculated from the transverse test, is 11,500,000. From the results obtained by the alloys of this series, it is evident that it does not necessarily follow that two alloys which are separately good and strong, or poor and weak, and are composed of different metals, will, when cast together, give an alloy which is similarly strong or weak.

2d Series.—This series was made up to enable a closer approximation to be made before investigating details. In this set 36 alloys were made by allowing all possible combinations obtainable by a difference of 10 per cent. in three metals. They were 9 inches long and from most of them two specimens were obtained. It was attempted to compress the bars of this series, while fluid; but it was found impracticable owing to the small amount of metal. In the few cases in which the compression was made, the effect was so trifling that no increase of strength could be noticed. In general, the bars of this series were not as strong as those of the first series; this may have been due to the fact that the other bars were nearly three times as long and were thus cast under a greater pressure. From the triangle of maximum torsional moments we notice that if the amount of tin does not exceed 40 per cent., the alloys are strengthened by an increase of copper up to 20 per cent. If a further addition of copper takes place, the alloys gradually become brittle, and when the copper amounts to 50 per cent., compositions are obtained which are so brittle as to be practically worthless. If more copper is added the alloys begin to increase in strength until a maximum strength is attained for the greatest percentage of copper in their series, *i. e.*, 80 per cent. When the amount of tin exceeds 40 per cent. the alloy becomes weaker as the percentage of copper is increased. Up to 20 per cent. of copper an increase of tin causes a decrease of strength and an increased ductility. Between 20 per cent. and 40 per cent. of copper it seems that the alloys become stronger for an increase of tin up to 20 per cent. They then

become weaker as the tin is further increased. When the amount of copper exceeds 40 per cent. an increase of tin again appears to weaken the alloy; this is only true when the least quantity of tin amounts to 10 per cent., as in this series. The results of the tests of this series show that more than five-sixths of the possible alloys are comparatively worthless and that it would not be worth the expense and time necessary to investigate this part of the field more fully.

3d Series.—This series consisted of 24 bars of the same length as those of the first series. A line was drawn from 45 per cent. of copper on the zinc side of the triangle to 72·5 per cent. of copper on the tin side. These points represent the percentage at which the change of color and increase of strength in the brass and bronze alloys takes place. The alloys of this series were all located in the portion of the field containing all the more useful compositions and they were made to vary in regular order by 5 per cent. The castings of this and subsequent series had smoother surfaces than those of the preceding and none of the bars were broken in the mould. A volatilization of the zinc took place during the pouring of the molten metal in the first three numbers of the series. Mr. Coster found a great difference in the results obtained from the upper and lower ends of the bars; the upper end giving the more favorable results; thus, in one case, the upper end had a maximum abscissa of 53·2° while the lower end was turned through an angle of but 9·9° when it broke. The great difference between the curves of these two portions of the bar can be imagined when it is known that the former had an ordinate of 0·92 inch at the elastic limit and a maximum ordinate of 1·76 inches, while the other end had for its ordinate at the elastic limit 1·38 inches and for a maximum ordinate 1·56 inches. The general laws followed by the curves representing the properties of the alloys of copper, tin, zinc were approximately determined from the results of the test of this series. For a certain amount of copper (when this exceeds 50 per cent.) an addition of tin increases the brittleness, while zinc increases the ductility of the alloy. If the amount of copper is increased it is necessary also to increase the tin in a certain ratio in order to obtain an alloy of about the same percentage of ductility. It was shown by the result of tests of this series that 5 per cent. of tin will cause the alloy to be brittle, unless it contains about 65 per cent. of copper. When the composition has 80 per cent. of copper, 10 per cent. of tin will make it quite ductile, while 15 per cent. of tin will render it rather

brittle. Hence the amount of tin necessary to make a useful and strong alloy, when there is 80 per cent. of copper, lies somewhere between 10 per cent. and 15 per cent, and an alloy composed of Cu 80, Sn 12·5, Zn 7·5 will very nearly represent the best proportions.

4th Series.—This series consisted of but five alloys which were chosen without regard to regularity in difference of composition, but to determine some doubtful points previous to the preparation of the final series. No. 1 (Cu 55, Sn 0·5, Zn 44·5) contained but 0·5 per cent. of tin and is the only instance in the entire investigation where so small an amount of any of the metals was introduced in an alloy. This was done in order to ascertain the effect of so small a percentage when added to an alloy of known properties. This alloy was brass (Muntz metal, nearly), and 0·5 per cent. of tin was substituted for zinc, thus leaving but 44·5 per cent. of zinc. The smallest quantity of zinc in any of the bars of the series was 2·5 per cent. in No. 5 (Cu 82·5, Sn 15, Zn 2.5). The weighings, castings, etc., were made as before. The great difference in ductility between the two ends of the bars, alluded to in the preceding series, was more marked in No. 2 (Cu 67·5, Sn 5, Zn 27·5) than in any other alloys thus far tested. The upper end, No. 2 A, was turned through an angle of 70·8°, while the lower end, B, broke after it was turned through 7·5°, the latter being only about 10 per cent. of the former. This difference of structure was exhibited, in a more or less marked degree, by all the bars of this series.

5th Series.—From the results of the preceding series, it was concluded that the most useful alloys which remain to be investigated are located between the line drawn from 88 per cent. of copper on the bronze side of the triangle to 65 per cent. of copper on the brass side, and from 83 per cent. of copper on the bronze side to 55 per cent. on the brass side. The alloys in this part of the triangle were now made, varying by 2·5 per cent., omitting those which had already been tested and a few which were not absolutely necessary to the determination of the laws of variation of strength. The series consisted of twelve bars of the same length as those of the 1st, 3d and 4th series. No changes were made in the methods of weighing or casting. The results obtained fully confirmed the previous determinations. It was found that, in nearly all the bars, the upper portion was considerably more ductile than the lower and also generally stronger. All the bars of this series were strong alloys; the strongest, No. 1 (Cu 60, Sn 2·5, Zn 37·5), had a mean maximum torsional moment of 216 foot-pounds,

and the weakest, No. 7 (Cu 72·5, Sn 10, Zn 17·5), 15.2 foot-pounds. It appears from these results that all the alloys located between the lines forming the boundaries of the set of compositions experimented on in this series are useful and strong. Commencing with the strong brasses on one side of the triangle, greater strength is obtained when any appreciable amount of tin is added: as the quantity of tin is increased, the alloys continue to be superior in strength to either the brasses or the bronzes; but their strength gradually decreases with the diminution of the amount of zinc, if the alloy contains more than 60 per cent. of copper, until we obtain the strong bronzes on the other side of the triangle. An addition of tin for the same amount of copper, if this does not exceed 30 per cent., increases the ductility of the alloy. In alloys containing 40 per cent. of copper a substitution of tin for zinc does not seem to affect the ductility either one way or the other. If the alloys contain more than 40 per cent. of copper an increase of tin always causes a decrease of ductility. The most ductile alloy was No. 8 B, 2d series (Cu 10, Sn 80, Zn 10), which had an angle of torsion of 418·4°; none of the other alloys tested contained such a large quantity of tin. From the percentage of extensions of the alloys having a torsional moment of more than 150 foot-pounds, and strength of more than 35,000 pounds per square inch, four curves of maximum strength with a certain percentage of extension have been constructed. The lowest curve thus plotted on the triangle has an extension of 0·03 per cent. and connects the points representing the strong brittle alloys. It starts at 43 per cent. of copper on the brass side and cuts the bronze side of the triangle at 77 per cent. of copper. The other curves have an extension of 3, 7·3, and 17 per cent. respectively. They all appear to converge to a point to the right of the brass side and agree nearly with arcs of circles of about 14 inches radius. By means of these curves of extension alloys of different degrees of ductility can be selected. (See Fig. 5.)

General Remarks.—The effect of tin upon alloys of copper and zinc can be compared to that of carbon on wrought-iron. Commencing with brass of about 55 per cent. of copper, which is of itself ductile and strong, we obtain by the addition of a small percentage of tin an alloy of much greater strength, having a higher modulus of elasticity, but not quite as ductile. By further addition of tin, up to about 2.5 per cent., the alloy becomes gradually less ductile, but it increases in strength. If more tin is added we obtain compositions which become

more brittle as the tin is increased, and at the same time decrease in strength. A slight modification of proportions often causes very great changes in the properties of the alloys, as has been noticed in No. 1, 4th series, where 0·5 per cent. of tin, added to ordinary brass, resulted in giving an alloy stronger than wrought-iron.

(To be concluded.)

"THE BRITISH PATENTS, DESIGNS, AND TRADE-MARKS ACT OF 1883," IN ITS RELATION TO AMERICAN INVENTORS.

By G. MORGAN ELDRIDGE.

[Read at the Stated Meeting, Wednesday, December 19, 1883.]

On the first of the coming year a new enactment goes into operation in England, which to some extent modifies the present patent system of that country; and in view of the fact that many citizens of the United States have already taken out patents there, and that under the new law many more will probably do so, it is well to consider the condition of things under the new régime, especially since sundry contradictory, and some incorrect statements have appeared in the public prints in regard to it.

To commence with one very important point, it has come to be generally supposed that publication or introduction of a new invention may then be made there for six months, before applying for a patent—as they may be for two years in the United States—without injury to the application. This impression, however, is entirely erroneous, as the old law in that respect is unchanged, unless under circumstances which are very exceptional and do not affect the general rule.

This appears by section 26, which provides that "Every ground on which a patent might at the commencement of this Act be repealed by *scire facias* shall be available by way of defence to an action of infringement, and shall also be ground of revocation."

One of the exceptions relates to an exhibition of the invention at an industrial or international exhibition, and another to patents, designs, and tradesmarks in such foreign States as have made mutual arrangements with England for that purpose; and the precision with which these exceptions are stated, only more clearly defines the general rule.

Section 39 provides as follows: "The exhibition of an invention at an industrial or international exhibition, certified as such by the Board of Trade, or the publication of any description of the invention during the period of the holding of the exhibition, or the use of the invention for the purpose of the exhibition in the place where the exhibition is held, or the use of the invention during the period of the holding of the exhibition by any person elsewhere without the privity or consent of the inventor, shall not prejudice the right of the inventor or his legal representative to apply for and obtain provisional protection and a patent in respect of the invention or the validity of any patent granted on the application, provided that both the following conditions are complied with, namely:

"*a.* The exhibitor must, before exhibiting his invention, give the comptroller the prescribed notice of his intention to do so; and,

"*b.* The application for a patent must be made before or within six months from the opening of the exhibition."

To analyze this, which is strictly exceptional, and therefore goes to the extent of its letter, and no further, will show within what narrow limit even this privilege is allowed.

The right to apply for a patent, and the validity of the patent itself when granted, are not prejudiced only in the case that the exhibition is at an international or industrial exhibition, certified to be such by the Board of Trade; that the exhibitor before exhibiting his invention, has given the comptroller the prescribed notice of his intention; that the invention is used only for the purpose of the exhibition and in the place where the exhibition is held; that during the holding of the exhibition any use by any person elsewhere is without the privity or consent of the inventor; that publication of a description of the invention be made only during the period of the holding of the exhibition; that application for a patent be made within six months from the opening of the exhibition: or, to state the converse of the proposition, if the invention be exhibited at an exhibition not so certified, or at such certified exhibition without the prescribed notice to the comptroller, or at any other place or time or for any other purpose, than at and during the holding of the exhibition, and for the purpose of the exhibition; or if it be used by any person elsewhere during the holding of the exhibition with the privity or consent of the inventor; or if any description of the invention be published except during the period of the holding of the exhibition; or if application be not made within six months,

the right to a patent is lost, and the privilege of six months is practically limited to the period of the exhibition, as will plainly appear, because, the use of the invention by the inventor on any day after the close of the exhibition takes him out of the exception of this clause; the use of the invention by any person anywhere on any such day, with or without his knowledge, has the same effect; and a publication of a description of the invention, though not producing that result while the exhibition remains open, becomes thus operative the day after it has closed, and bars his rights.

The other exception is one which is not likely to become operative in the United States.

Section 103 provides, that if any arrangement is made with any foreign State for the mutual protection of inventions, designs, or trade-marks, the person who has applied for protection in such State shall have priority over other applicants, in the case of a patent for seven months, and in the case of a design or trade-mark for four months, and that publication of a description of the invention or the use thereof in England during that time shall not invalidate a patent therefor, this exception being limited to States to which it shall be declared applicable by Order in Council, which is revokable at discretion.

It is not probable that this provision will ever become applicable to the United States, because such mutual arrangement could enure only to the benefit of citizens of the United States, and not at all to subjects of England, who have now not only seven months, but two full years during which they may apply for patents without prejudice by reason of publication or use, and therefore there is nothing to be given in return for the privilege.

The only additional exception is that the communication of an invention for an improvement in instruments or munitions of war to the Secretary of State for investigation, and anything done by him in such investigation shall not prejudice the rights of the inventor.

Any person or persons, English or foreign, may apply for a patent. The Act provides (§4), that the applicant shall declare that he is in possession of an invention of which he claims to be the true and first inventor, and for which he applies for a patent. No definition is given of the word inventor, but an invention is defined to be (§46) any manner of new manufacture the subject of letters patent within Section six of Chapter three of the twenty-first year of King James the First, and is stated to include an alleged invention, which leaves the meaning

of the word inventor as under the old law in which it is synonymous with introducer. It is to be noted that while the applicant declares that he is the true and first inventor, the word original is nowhere used; so that plainly, under the new law, as under the old, the original inventor has no rights which the introducer is bound to respect.

Amendments and disclaimers may be made, substantially as reissues and disclaimers are allowed under the American system, it being provided that no amendment shall be allowed that would make the specification substantially larger than or different from the invention originally covered, with the difference, that leave to amend is conclusive as to the right of the party to amend except in case of fraud, which takes away the question, so important in the United States, of variance between the original patent and the reissue; that a disclaimer may be made pending a suit, the hearing on which is postponed for that purpose, and then goes on as if the disclaimer had been previously made; and that, a very important difference (Section 20), "Where an amendment by way of disclaimer, correction or explanation has been allowed under this act no damages shall be given in any action in respect to the use of the invention before the disclaimer, correction or explanation, *unless the patentee establishes to the satisfaction of the Court that his original claim was framed in good faith and with reasonable skill and knowledge.*"

While, undoubtedly, the drift of the decisions of the Supreme Court of the Uuited States in regard to reissues is to the public interest, it is worthy of consideration whether the exception in Section 20 might not, if introduced here, serve the ends of justice better than they are served by the present law, which sometimes works great hardship.

Compulsory licenses may be ordered by the Board of Trade on terms fixed by it in case—

a. The patent is not being worked.

b. The reasonable requirements of the public are not supplied.

c. "Any person is prevented from using to the best advantage an invention of which he is possessed;" which last opens a wide door.

It would be well to consider whether some provision of this nature might not advantageously be introduced in the United States.

A patent under the new law binds the Crown, but the invention may be used by the Government or by Government contractors on terms to be agreed upon, or, in default of an agreement, on terms to be settled by the Treasury after hearing the parties interested.

An invention may be used on a foreign ship in British ports, not-

withstanding an English patent, provided that similar privileges are allowed to British ships in the State to which such ship belongs.

Any person who, by advertisement or otherwise, threatens prosecution for infringement of a patent, and does not bring a suit, is liable to an action for damages if the thing as to which he makes the threat be not an infringement of his patent, and he may be restrained by injunction from the continuance of such threats, which provision, if in force here, would save annoyance.

A patent is to be for one invention only, but it is not ground of objection that it is for more than one. It must have a claim, and may have more than one.

Section 26 (8) provides, "Where a patent has been revoked on the ground of fraud the comptroller may, on the application of the true inventor made in accordance with the provisions of this Act, grant to him a patent in lieu of and bearing the same date as the date of revocation of the patent so revoked, but the patent so granted shall cease on the expiration of the term for which the original patent was granted."

This, to this extent, takes out of the Patent Office and into the Courts the question of conflicting claims to the same invention, and where it is there determined that the holder of the patent is not the one entitled it, not merely revokes the patent wrongly held, but practically transfers it, for the remainder of its term, to the successful litigant who is decreed to be its proper owner.

It is worthy of consideration whether some provision of this nature might not be adopted in the United States, by which proceedings in interference, now so productive of expense and fruitless of result, might be transferred from the Patent Office, which can now only give to the applicant who appears best entitled, a patent which is again newly assailed so soon as the patentee attempts to enforce it, to a Court which could bring before it all the parties claimant, decide in favor of one and grant him a patent, and by decree binding on all the world, to be noted on the patent, debar defence to that patent on any ground which would have entitled either of the others to a patent for that invention. Such parts of each application as were not in interference could proceed, and patents on them could be issued in the regular way, and only the precise question in interference would come before the Court and be the subject of its decree. The Patent Office could settle the form

of the patent to which some one of the contestants would be entitled, and in that form turn over the question to the Court.

This would probably be no less expensive than the interference or the generally consequent suit, but it would be only as expensive as one of them and would definitively and perpetually close controversy upon the subject.

Every application filed is referred to an examiner, who reports whether the nature of the invention has been fairly described, whether the papers have been prepared in the prescribed manner, whether the title sufficiently indicates the subject matter of the invention, and, in case there is on file at the same time an application bearing the same or a similar title, whether they both comprise the same invention, in which latter case, if such is found to be the fact, "the comptroller may refuse to seal a patent on the application of the second applicant."

Opposition to the grant of a patent may be made by any person on the ground of the applicant having obtained the invention from him; or on the ground that the alleged invention is covered by an existing English patent or a prior application, but on no other ground; which provisions define the limit of investigation as to the novelty of the invention, and leave in operation, with these exceptions, the present system of granting to any one a patent for anything he asks, with no approach to the advantages which are offered to the applicant for a patent in the United States by the system which is in operation here.

These advantages, great as they are, are by some not clearly understood, and therefore not fully appreciated.

It is to be borne in mind that a patent whose claim covers a thing previously known or used is inoperative and invalid. Such prior knowledge or use may be divided into two classes; a published description in some patent or other publication; and the manufacture, use or sale of the thing claimed as new, as to which there has been no published description.

As to the last, it is in its nature that it cannot with certainty be known to any person by the most careful research, for a use of a thing in a factory or shop, or by a limited number of persons outside of such place, may be so far public as to invalidate a patent for it and at the same time so far private that only by the merest accident can it be discovered by any one elsewhere.

As to such obstructions, both systems stand on an even footing, and they are to be compared only by their relation to published matter.

Considered only in such relation, if a patent claim covers matter so published the patent is void, otherwise it is valid, and that equally in both countries. The experience of every one who has taken out a patent in the United States will show him that the case is rarely exceptional in which the claims as first presented are not liable to the objection that they cover old matter, and that therefore the patent, if issued in that form, would be invalid.

In England the patent would be issued in that form, and the patentee would be left to discover, at the end of a law-suit, and after he had exhausted his means in the introduction of his invention, in which he supposed himself protected, that his patent was inoperative and his protection had failed.

In the United States the application is referred to the examiner, who has charge of that branch of that subdivision of that class of inventions, who has before him the results of the careful research, for years, of the publications relating to that special detail of the subject brought down to the latest date, and he advises the applicant as to every objection which can be found to his claims in any publication in the world, which objection, if well founded, would invalidate his patent if issued in that form, whenever and by whomsoever discovered.

If the objection be not well founded the applicant can obtain his patent regardless of it. If it be well founded and goes to the entire extent of the novelty of the supposed invention, the applicant finds that, though he was an original, he was not the first inventor, and he retires from the contest, which is the best for him; if he has nothing, the sooner and the more cheaply he learns it the better.

If, as is generally the case, he has really invented something new—but has claimed more than was new—he learns what portion of it is old, and he limits his claim to that which is really his; and he has a very good assurance that, so far as published matter is concerned, when he takes out his patent in this form, he has that which will effectually prevent any one from making, vending, or using the thing covered by his claims.

If, when the process of elimination is completed, he finds that what is left is of no value to him, he need go no further; which, again, is good for him; he knows, or can know, exactly upon what ground he stands.

All this he obtains for the preliminary fee of fifteen dollars paid into the Patent Office; a result which he could not obtain otherwise for that

sum, nor scarcely for any sum. No individual research can cover the ground so well as it is covered by the system of minute subdivision of the Patent Office, and no approach to it could be made at the price; and, in default of it, the patentee is left to obtain the information when the cost of it may be his destruction.

If the patentee supposes—as from ignorance many suppose—that he acquires by his patent a right to make the whole machine of which his claim covers a part, and proceeds upon that presumption, he may thus get into trouble. A patent authorizes a man to do nothing, but only enables him to prevent another from doing something, and no system of government protects a man against the consequences of his own ignorance or folly.

There is an impression among some that the Patent Office habitually grants patents which cover old matter and have no novelty, but it will be found that this criticism comes from those who are uninformed as to the above proper rule of construction, or who have not examined the claims of the patents they criticise, and are therefore not aware how restricted they are and how little ground they actually cover. This is not to be ascribed as a fault but to be counted as a merit to the Patent Office. Little as the thing is, it is all of which the patentee was the original and first inventor; and little as the thing appears, it is sometimes such a little thing which bridges the gap between a machine which is a failure and one which is a success, and the patentee has the assurance that—though little—it is all that he is entitled to and that he is entitled to it.

It may be said that the Patent Office examiners sometimes fail to discover matter which makes a good objection to the claim; which is true, and is partly the result of the fallibility of all human systems and partly the result of the niggardly system pursued by the government of the United States in relation to the Patent Office producing a corps of examiners insufficient in number and in quality. In number, because not enough are provided; in quality, because experience is the only thing which can give the desirable approach to perfection, and when an examiner has obtained this experience he finds that the pay of his position is not equal to what he can gain elsewhere, and he therefore leaves his place to another who has the experience to acquire.

If the government would devote to the use of inventors the money which it receives through the Patent Office from them, this state of things would not exist. A highly meritorious and hard-working class

of officers would be increased to the number required and would be paid according to their desert, and would therefore remain in their positions; the plan of subdivision of subjects would be more thoroughly and perfectly carried out; and, as a consequence, the number of errors would be greatly diminished, and the whole system would approach in practice very nearly to the perfection which it has in theory.

CAST IRON IN STEAM BOILERS.

By S. Lloyd Wiegand.

[Read at the Stated Meeting, Wednesday, January 16, 1884.]

Public attention has been recently directed to the fact that cast iron is extensively used in the construction of boilers, and most notably in the heads of cylinder boilers. Many such boilers have flat heads, and expressions of opinions, alleging flat cast iron boiler-heads to be dangerous, have been recently made, and reiterated in terms and with a frequency calculated to excite grave alarm, not only on the part of the owners and users of such boilers, but in the minds of the public generally, and to produce an impression that such boilers are necessarily a menace to property and life.

The criticisms against such structures have not assumed any such exact expressions, as to show where safety ceases and danger begins, but they have been condemned apparently without a hearing, as dangerous and treacherous always, and under every condition.

The published engineering literature throws very little light on this subject, and no recent treatise, or for that matter, old ones either, give any rule for computing the strength, or determining the proper proportions of such boiler-heads, yet thousands of them are in daily use, and more of them are being made.

That there must be some merit in them, is a reasonable inference from their extensive use, and to open a discussion on their merits and faults, and to bring to the attention of the Institute evidence of what they are capable of enduring, is the purpose of this paper.

To bring the matter more clearly to the observation of this meeting, it is proposed to repeat an experiment recently made in this City, of testing a cylindric boiler, provided with flat cast iron heads, by hydraulic pressure, and

1st. To show the limit of elasticity in force and motion of such heads.

2d. The relative strength of the heads and the riveted shell.

3d. The manner of rupture of the head by internal pressure; and

4th. The pressure required to rupture the head.

The dimensions and form of the head and boiler shell are stated upon the sectional diagram; they are further illustrated by models, made to a scale, which may serve to give a better conception of the proportions of the boiler under test.

The testing operation consists in simply filling with water, taking care to exclude all air, and afterwards gradually applying hydraulic pressure by a pump, and observing the pressure, and at the same time measuring the inflation or dilation of the head, relieving the pressure, repeating this operation several times with increasing pressure, and observing at what pressure the head becomes permanently set, or bent outward, and finally applying and observing increased pressure until the vessel breaks.

The same experiments made with a vessel exactly similar to this one, showed that no permanent set of the head took place until a pressure of 225 lbs. per square inch was applied. At that pressure the inflation at the centre of the head measured, as nearly as could be ascertained ·135 of an inch.

Before any rupture of the heads occurred, the riveted longitudinal seam leaked, so as to require very active pumping to raise the pressure above 380 lbs. per square inch, and the bursting took place at 455 lbs. per square inch, the breaking commencing at the manhole opening of one head, and extending radially outward toward the rim and the flat plate, breaking inside of and partially through the fillet, in the angle formed by the rim or flange and flat plate of the head.

As a matter of interest in this connection, there is herewith submitted to the meeting, broken parts of a flat cast iron boiler head, which wore out and survived three wrought iron shells working under pressure of 100 lbs. per square inch, and which only showed a great defect (of being in fact two layers of metal united only at the edges) when it was broken up to remelt, it having been discarded solely because of its dimensions.

It is respectfully suggested, that although cast iron has not all the properties that might seem desirable in the construction of apparatus to sustain internal pressure, it is, and will in all probability for a long time remain one of the most easily available materials for mechanical

structures, and instead of finding fault with it in general terms, and condemning its use by unmeasured terms of reproach, it is far more desirable that whatever information, of a reliable character, in reference to its proper useful and safe application to such structures is procurable, should be put in some accessible shape, and made generally known.

Entertaining these views, it is proposed that when new business is in order at this meeting, to submit the following resolution:

Resolved, That the Committee on Science and the Arts, be requested to ascertain and report the properties and strength of cast iron, as a material for the construction of boiler-heads and other vessels for retaining fluid under pressure, together with such rules for estimating the strength and proportioning of such structures, in the different forms now in use, with economy and safety, and also the proper modes of testing and using such structures, as will be useful to those practically engaged in the manufacture and use thereof.

Studies of the Aurora.—Tresca gave a flattering testimonial to the ingenuity and success of Prof. Lemström, on laying before the French Academy the results of the experiments in Lapland for producing artificial auroras. He considers that Lemström has demonstrated, by those experiments, that in extreme northern latitudes, and at a temperature of −30° (−22°F.), the polar aurora is an electric phenomenon, which may be represented by atmospheric currents of a magnitude corresponding to a current which would be produced by a Leclanché cell of moderate size. The natural manifestation of this current gives place, even in the absence of any other illumination, to a local aurora, which is visible above the apparatus, and in which can be seen the characteristic line, $\lambda = 5{,}569$. We are thus able to recognize, with complete certainty, the existence, and even the magnitude, of the electric forces which are brought into play. During the coming winter Prof. Lemström proposes to continue his researches, with the view of determining the proper construction of apparatus for giving currents of the greatest intensity; the relation between the extent of surface and the intensity of current; the variation of current with differences of latitude and with differences of altitude between the two extremities of the apparatus; the influence of the seasons; and the relations between the atmospheric current, the terrestrial current, and the magnetic variations.—*Comptes Rendus*, May 7, 1883. C.

ELECTRO-PLATING WITH NICKEL.

By WILLIAM H. WAHL.

[A paper read before the Chemical Section of the Franklin Institute, Nov. 6, 1883.]

(Concluded from page 134.)

The results of extended practical trials of Mr. Weston's formula, made by the writer, have convinced him of the substantial correctness of the claims of this inventor. Where the double sulphate of nickel and ammonium is is used the addition of boric acid in the proportion of from 1 to 3 ounces to the gallon of solution gives a bath less difficult to maintain in good working order, and affords a strongly adhesive deposit of nickel. The deposited metal is dense and white, approaching in brilliancy that obtained from the solution of the double cyanide.

In 1880, J. Powell,* of Cincinnati, patented an electro-depositing solution "composed of the pyrophosphate of soda phosphate of nickel, the bisulphite of soda, and citrate of nickel and ammonia."

In the same year C. G. Pendelton,† of New York, patented the use of an acid solution of the acetate of nickel. The inventor emphasizes the caution that this solution must always be kept acid. The metallic strength of this solution is fully maintained by the solution of the anodes, and the bath consequently requires no additions of fresh salt.

An interesting suggestion is that patented in 1880 by Mr. Powell,‡ and which covers the use of benzoic acid in nickel-plating solutions.

In describing his improvement Mr. Powell calls attention to the fact (?) that simple salts of nickel cannot be used on account of their failure to yield a regular deposit. He claims to have discovered that the addition of benzoic acid to any of the nickel salts, arrests in a marked degree the tendency to an imperfect deposit, and prevents the decomposition of the solution and consequently the formation of sub-salts. The amount of benzoic acid necessary to be added to the bath for this purpose is said to be $\frac{1}{8}$ ounce to the gallon of solution. He, therefore, claims "an electro-depositing solution consisting of a soluble salt of nickel, its solvent, and benzoic acid." This bath is reported to give very satisfactory results.

In the same year, Mr. J. H. Potts,‖ of Philadelphia, was granted a

* Consult U. S. Pat., No. 228,389, June 1, 1880.
† Consult U. S. Pat., No. 232,615, September 28, 1880.
‡ Consult U. S. Pat., No. 229,274, June 29, 1880.
‖ Consult U. S. Pat., No. 232,755, September 28, 1880.

patent for an improved solution for the electro-deposition of nickel "consisting of the acetate of nickel and the acetate of lime with the addition of sufficient free acetic acid to render the solution distinctly acid." Mr. Potts prepares his bath as follows: He precipitates the carbonate of nickel from a boiling aqueous solution of the sulphate by the addition of bicarbonate of sodium, filters and dissolves the well-washed precipitate in acetic acid, with the aid of heat.

The acetate of calcium he prepares by treating caustic lime, or the carbonate (marble-dust) with sufficient acetic acid to dissolve it with the aid of heat. The solution of these salts is acidified, slightly but distinctly, with acetic acid.

This solution, which I have worked with under a variety of circumstances, is in many respects an excellent one. It gives satisfactory results, without that care and nicety in respect to the condition of the solution and the regulation of the current which are necessary with the double sulphate solution. The metallic strength of the solution is fully maintained, without requiring the addition of fresh salt, the only point to be observed being the necessity of adding, from time to time (say once a week), a sufficient quantity of acetic acid to maintain a distinctly acid reaction. It is rather more sensitive to the presence of a large quantity of free acid than to the opposite condition; as in the former condition it is apt to produce a black deposit, while it may be run down nearly to neutrality without notably affecting the character of the work. The deposited metal is characteristically bright on bright surfaces, and requiring but little buffing to finish. It does not appear, however, to be as well adapted for obtaining deposits of extra thickness as the commonly used double sulphate of nickel and ammonium. On the other hand, its stability in use, the variety of conditions under which it will work satisfactorily, and the trifling care and attention it calls for, make it a useful solution for nickeling.

FORMULÆ FOR NICKEL-PLATING SOLUTIONS.

No. 1.

Double sulphate of nickel and ammonium.....	5 to 8 parts.
Water.....	100 "

Dissolve the nickel double salt in above quantity of water with the aid of heat. Cautiously add ammonia, or the sulphate of ammonium, until the solution is neutral to test-paper. This solution should be

maintained as nearly neutral as possible in use. This is commonly known in the United States as the Adams solution. It is in very general use by nickel-platers throughout the United States, and yields, where properly managed, excellent results.

No. 2.

Double sulphate of nickel and ammonium	10 parts.
Boric acid (refined)	2½ to 5 "
Water	150 to 200 "

(Weston's solution.) The superiority of this solution is generally acknowledged. The deposited metal, as previously remarked, is almost silver-white, dense, homogeneous and tenacious, and the solution maintains its excellent working quality very uniformly in long-continued service.

The nickel salt and boric acid may be dissolved separately in boiling water, the solutions mixed, and the volume brought up to that of the formula, or the two components may be dissolved together.

No. 3.

Acetate of nickel	2¾ parts.
Acetate of calcium	2½ "
Water	100 "

To each gallon of this solution add 1 fluidounce acetic acid, 1·047 sp. gr.

To prepare this bath, dissolve about the same quantity of the dry carbonate of nickel as that called for in the formula (or three-quarters of that quantity of the hydrated oxide) in acetic acid, adding the acid cautiously, and heating until effervescence has ceased, and solution is complete. The acetate of calcium may be made by dissolving the same weight of carbonate of calcium (marble-dust) as that called for in the formula (or one-half that quantity of caustic lime), and treating it in the same manner. Add the two solutions together, dilute the volume to the required amount by the addition of water, and then to each gallon of the solution add a fluidounce of free acetic acid, as prescribed. (Potts' solution.)

No. 4.

Sulphate of nickel and ammonium	10 parts.
Sulphate of ammonium	4 "
Citric acid	1 part.
Water	200 parts.

The solution is made with the aid of heat, and, when cool, small fragments of carbonate of ammonium should be added until the bath is neutral to test-paper.

No. 5.

Sulphate of nickel	6 parts.
Citrate of nickel	3 "
Phosphate of nickel	3 "
Benzoic acid	1½ "
Water	200 "

No. 6.

Phosphate of nickel	10 parts.
Citrate of nickel	6 "
Pyrophosphate of sodium	10½ "
Bisulphite of sodium	1½ "
Citric acid	3 "
Aqua ammonia	15 "
Water	400 "

(Powell's solutions.) These solutions yield good results, but their complex composition must debar them from general use.

No. 7.

Sulphate of nickel	6 parts.
Aqua ammonia	3 "
Water	100 "

When the nickel is dissolved, add—

Aqua ammonia	20 parts.

This bath is similar to that recommended by Prof. Boettger; it is said to be well suited for the purposes of amateurs, inasmuch as it gives good results with a platinum anode. It is worked at a temperature of 100° Fah., with a moderate current. It requires renewal from time to time, as it becomes impoverished in nickel, by addition of fresh nickel salt; it must also be kept alkaline by the occasional addition of ammonia.

No. 8.

Sulphate of nickel and ammonium	10 parts.
Sulphate of ammonium	1½ "
Water	250 "

Dissolve in boiling water and allow to cool. These proportions are recommended for coating objects of cast and wrought iron and steel.

No. 9.

Sulphate of nickel and ammonium	10 parts.
Sulphate of ammonium	2 "
Water	300 "

Dissolve as above. Recommended for coating brass, copper, tin, Britannia, lead, zinc, etc.

No. 10.

Sulphate of nickel and ammonium	6 parts.
Chloride of ammonium (sal-ammoniac)	3 "
Water	100 "

Watt* recommends for ordinary purposes the following solution, which he affirms will give in careful hands very good results. "Take say 2 ounces of pure nickel, dissolve in hydrochloric acid, taking care not to have an excess. A gentle heat will assist the operation. When dissolved, dilute the solution with 1 quart of cold water. Now add ammonia gradually, until the solution is quite neutral to test-paper. Next, dissolve 1 ounce of sal-ammoniac (chloride of ammonium) in water, and mix this with the former solution. Lastly, evaporate and crystallize slowly." The resulting salt will be the double chloride of nickel and ammonium. It is one of the earliest solutions used for nickel-plating by Smee and Gore, and is affirmed by these writers to give good results. Watt has also obtained excellent results with the double chloride. According to Smee, the simple chloride of nickel will yield a deposit having a very brilliant lustre.

I can unqualifiedly confirm the statement of Gore† that the electro-deposit obtained from a solution of the double cyanide of nickel and potassium is "nearly equal in whiteness to silver." I have obtained deposits with this solution, of such extreme whiteness and beauty as to deceive even an expert on casual inspection into the belief that they were silver. The bath, however, rapidly loses its activity and runs down, and is so difficult to manage that it is impracticable for general use. This, at least, is the opinion I have reached after many trials of it. I am informed, nevertheless that it is successfully used on the large scale in certain nickel-plating works in this country, though I have not been able to substantiate the fact.

To prepare this bath make a solution of any salt of nickel, and add cyanide of potassium solution so long as a precipitate continues to be

* Watt, *Electro-Metallurgy* (7th ed.), p. 94.
† Gore, *Electro-Metallurgy* (1877), p. 233.

formed, being careful to avoid adding an excess. Then remove the liquid either by decantation or filtration; and after several washings dissolve the precipitate almost to saturation in cyanide of potassium solution. Make a completely saturated solution and add a small quantity of free cyanide of potassium. The brownish-red solution is then ready for use.

It may be added, in conclusion, that the double sulphate of nickel and ammonium is used most generally by electro-platers with nickel.

GENERAL OBSERVATIONS.

Where the double sulphate of nickel and ammonium is used, it is important that the operator should bear in mind the caution to maintain bath as nearly neutral as possible. There is a diversity of opinion the among nickel-platers upon this point, some preferring to operate with a slightly acid bath, while others prefer the opposite condition. Experience has shown that the solution will give satisfactory results either when slightly acid or slightly alkaline, and, as the chemical character of the bath during electrolysis is constantly being modified, it is manifestly impossible for the operator to do more than to keep his solution approximately in the right condition. A strongly acid solution will fail to give a deposit. When the bath therefore is found to be in this condition the addition of sufficient ammonia to restore its neutrality will bring it to working condition.

It is only by accident or carelessness, however, that the solution will become inoperative from this cause, as the chemical changes which occur in the solution of this salt, under the influence of the electrical current, and under the conditions in which it is commonly used in the plating bath, are such as to cause it to gradually assume an alkaline character. This is due to the fact that not simply sulphate of nickel, but to some extent also, sulphate of ammonium, undergoes decomposition into its proximate constituents. The sulphuric acid set free by the decomposition of the ammonium sulphate will form an equivalent quantity of sulphate of nickel by solution of the anode, while the ammonia will remain free, and gradually, as it accumulates, will impart a decided alkalinity to the bath. The more intense the current employed, the more rapid will be the decomposition of the solution and the liberation of free ammonia. As this change progresses, the quality of the work is more or less unfavorably influenced. Accom-

panying this change, especially where the current employed is irregular and at times too intense, there is also a precipitation of some of the nickel, probably in the form of basic salt, by which the metallic strength of the bath is impaired, and which necessitates the addition of fresh quantities of the double sulphate from time to time. Where a current of only moderate intensity is used, and which is uniformly maintained, these difficulties will be reduced to a minimum, and the solution will maintain itself in good working order for a long time, requiring only the occasional addition of a little sulphuric acid to correct any pronounced alkalinity that may be exhibited when tested as it should be at frequent intervals, with test-paper. As metallic nickel is difficultly soluble, the use of comparatively large anode surfaces is necessary, because the nickel dissolves so slowly that if the anode surface exposed in the depositing vat is not considerably larger than that of the objects on which the deposit is made, the solution will not keep saturated. There is another reason for the use of a comparatively large anode surface, which will appear further on.

From the preceding remarks it will be unnecessary, perhaps, to add that the double sulphate solution commonly used by nickel-platers presents greater difficulties in its employment than the acid solutions of Potts and others.

Again, the strength of the current should be carefully regulated according to the surface of the articles in the bath, as otherwise the work will be apt to "burn;" that is, the metal will be precipitated a dark gray or black deposit, which discolors and renders it useless. This is evidence of a current of too great intensity. To obviate this difficulty, the plan is generally adopted by careful operators of suspending a plate of nickel, presenting considerable surface at both ends of the rod from which the articles are suspended in the bath. By thus diverting the current the "burning" of the work is prevented.

As a general rule, it is well to observe, that, other things being equal, the slower the rate of deposition, the more adherent and tenacious the coating of deposited metal will be. Where the metal deposits too rapidly, the deposit is apt to be brittle, and to exhibit, especially in the case of a heavy coating, a tendency to split and flake. This is due to the liberation of hydrogen at the cathode, and which is occluded by the electro-deposited metal. To obtain satisfactory results, it is important that the articles should be "struck," that is, receive a uniform coating immediately after they are immersed in the bath.

This is an indication that the articles have been properly cleaned, and are in proper condition to receive the deposit, and also that the bath is working properly. After this first layer has been deposited, the subsequent rate of deposition is much slower, for the reason that the deposit of nickel on nickel does not take place as readily as upon a foreign metal, a rule which appears to hold good of all metals.

Nickel solutions are feebler conductors of electricity than those of gold, silver, and copper, which is one of the reasons why its electro-deposition is attended with more difficulties than are experienced with the metals named. On this account, also, it is necessary to employ stronger depositing solutions than those used for gold and silver, and a stronger current. To make up for this want of conductivity it is advantageous to use a much larger anode surface than is customary with other metals, and it is necessary to place an anode on both sides of an article to be plated. The usual arrangement with a large vat is to have two rails of brass the whole length of the vat, resting on the edges of the same, from which two rows of cast or rolled nickel anodes (to which copper wires are soldered) are suspended. Between these outer rods is placed a similar one also running the whole length of the vat, and from this, by means of suitable slinging wires, the articles to be plated are suspended in the bath. The ends of the rails nearest the battery or dynamo are suitably connected therewith in the usual manner. The work thus hangs between the two rows of anodes.

Watt* very properly calls the attention of the operator in this connection to the importance of having the wire supports from which the articles are hung in the depositing vat, of a gauge suited to the character of the work. Small articles will require but a very thin wire, while larger ones will require correspondingly thicker "slinging wires." On the same point he cautions the operator that the difference of conductivity in the metals to be plated is to be considered, "for, whereas, a steel, brass, or copper article would become readily "struck," even if suspended from the conducting rod by a thin wire, articles of lead, Britannia metal, pewter, or even cast iron would not receive the deposit so readily." It is obvious, therefore, that in suspending articles in the plating bath, the operator must be guided in the matter of the thickness of the "slinging wires," by the nature of the articles, as well as by their dimensions.

* Watt, *Electro-Metallurgy* (7th Ed.), p. 104, *et seq.*

It cannot be too strongly impressed on the operator that the attainment of success in nickel plating depends very largely upon the perfect cleansing of the articles before they are immersed in the bath. Important as this operation is in plating with other metals, it is even more so in the case of nickel. Gilding, silvering, bronzing, etc., are usually effected with solutions having a decidedly alkaline character (reference is made here to the double cyanide solutions commonly used) and the presence of minute traces of oxide from careless exposure to the air after cleansing, or of grease from the fingers, etc., on the surface of the articles to be plated, is not necessarily fatal to the success of the work, as the free cyanide always present in those baths, being a solvent of greasy substances, and of metallic oxides, may remove trifling quantities of such impurities. With nickel, however, the case is different. The solutions employed for its deposition are either neutral, or weakly alkaline or acid. Their chemical character is such, therefore, that they can have little or no solvent effect on the grease or oxide left on the articles by careless cleansing, or improper handling or exposure before immersion; and if such articles are plated, the nickel coating at the unclean places will be found to have little or no adhesion to the metal beneath, and will almost certainly flake or strip at these places in the subsequent operation of buffing. Unless the surfaces to be coated are *chemically* clean an adherent deposit of nickel is simply impossible.

On account of the hardness of the deposited metal, nickel-plated articles cannot be burnished. In order, therefore, to obtain upon the finished work that suberb metallic lustre which characterizes this metal, it is necessary to polish the surface of the articles upon the buffing-wheel before immersion in the plating bath, in order that the deposited metal may be as smooth as possible; thus reducing the amount of subsequent buffing, required to finish the plated articles, to a minimum.

The operation of cleansing articles differs somewhat in various establishments; the following methods, however, are those usually followed.

For copper, brass, Britannia-metal, tin, pewter, etc., the articles are first steeped for a few minutes in boiling potash solution to remove greasy matter; they are then removed, dipped for an instant in cyanide of potassium solution of moderate strength, rinsed in water, again rinsed, then thoroughly brushed with the finest pumice powder (precipitated chalk and other fine powders are also used); again rinsed in

water, dipped again for an instant in the cyanide, well rinsed, and then hung at once in the nickel bath. The time of immersion in the boiling potash solution will depend on the strength of the alkali, and the amount of greasy matter present. Tin, Britannia, pewter, however, should be left in it as short a time as possible, as the alkali exerts a solvent action on tin and alloys containing this metal. When rinsed in water after removal from the potash, the water should wet the surface uniformly; should any cloudy patches be visible, these indicate that the grease has not been completely removed, and the article must be immersed again in the boiling potash.

Steel articles are first treated to the potash bath; rinsed in water, scoured with pumice powder (or its equivalent), rinsed, dipped for a moment in dilute hydrochloric acid, again rinsed, and at once hung in the depositing vat.

Cast iron is first placed in the potash bath to remove greasy matter, well rinsed, then allowed to remain for some time in a pickle of dilute sulphuric acid to partially dissolve off and partially soften the scale that covers it, rinsed, then thoroughly brushed with pumice, rinsed, dipped for a moment in dilute hydrochloric acid, again rinsed, and immediately placed in the nickel bath.

Many operators vary the above methods of cleansing somewhat, but they are followed substantially as given, by the majority of nickel-platers. With Britannia-metal, pewter, and other compositions of comparatively low conductive power, it is to be recommended to give them a preliminary coating of copper, for which purpose the cyanide bath is commonly employed. Many operators prefer also to copper articles of iron and steel preparatory to nickel-plating. The advantages secured are a better conducting surface upon which to lay on the nickel, and a more tenacious deposit, having in the case of a heavy coating of nickel less tendency to flake. Where a substantial and durable nickel deposit is required on iron and steel, and especially where the articles are to be exposed to the atmosphere, or will be subject to much handling, a preparatory coating with copper is almost indispensable. In the earlier days of nickel-plating it was the almost universal practice to first copper all iron and steel articles.

The enormous extension of nickel-plating of late years has caused its application to an endless variety of articles of trifling value merely to enhance their beauty, and this, together with the severe competition among those in the business has combined to cause a very general

deterioration in the quality of nickel-plated work. The necessity of doing cheap work is responsible for the fact, therefore, that thousands of articles are turned out of the nickel-plating works with the merest wash of nickel. The want of durability exhibited by these inferior goods has had the consequence that many have formed a low estimate of the utility of nickel as a protective coating for metals, which it is far from deserving.

It is important that the work should be examined very shortly after it has gone into the nickel bath, to observe whether it has been "struck" and its general appearance. Should dark streaks exhibit themselves upon the work, they may indicate either that the current is too intense, or that the work has not been properly cleansed. Such streaks will often be observed, starting from joints, seams, or rivets, where the grease from the buffing-wheel may have secured lodgment, and from which it is difficult to perfectly remove it. In such cases the work must be removed and given another thorough pumice brushing and rinsing, and again immersed in the depositing vat.

As has already been briefly noticed, the hardness of electro-deposited nickel renders it impossible to finish the plated articles by burnishing. It is, therefore, necessary to prepare the surfaces of the articles to receive the nickel deposited before they are plated, in order to reduce the subsequent finishing operations as much as possible. On this account it is customary to polish the surfaces of articles to be plated on buffing wheels. In case the surface is very rough, as is sometimes the case with articles of iron or steel, it may be necessary to grind it smooth upon the emery wheel. The work, when removed from the nickel bath, is dipped for a few moments into boiling water, and then rapidly dried in sawdust. It is now ready to be polished on the buffing wheels when it is finished.

The length of time required to produce a sufficiently heavy deposit of nickel will depend on the strength of the current, the condition of the bath, and the character of the articles. Brass and copper articles usually receive a sufficiently heavy coating in half an hour; for wares on which an extra-heavy coating is desired the time of immersion is extended to an hour or even longer. Iron and steel, Britannia-metal, pewter, etc., require a longer time of immersion than brass or copper, even though given a preparatory coating of copper, because of their comparatively inferior conductibility. A good coating of nickel, prop-

erly laid on, possesses great durability, and with ordinary usage will last for many years.

Old nickel-plated work which it is desired to replate should first be "stripped," as is found necessary with the precious metals, For this purpose a mixture of sulphuric and nitric acids is commonly employed. Watt* recommends the following mixture which will be found very serviceable, viz.: "4 pounds strong sulphuric acid, 1 pound nitric acid, and about 1 pint of water." By volume, these proportions would be approximately: Strong sulphuric acid 2 parts, nitric acid 1 part, water 1 part. The acids should be added to the water under constant stirring. This stripping liquid may be used either cold or slightly warm. It acts promptly, removing a light coating of nickel in less than a minute, and a heavy one in a few minutes. To avoid contaminating the solution as little as possible with the metal of the wares, the operation should be closely watched and the articles removed from the acid just as soon as the nickel has been dissolved. The preparation of the stripped articles for re-nickeling should be the same as for new work. Articles may be stripped in the nickel bath by the ordinary artifice of connecting them as anodes, but the practice is reprehensible, as the purity of the bath will thereby become impaired by the solution of the metals composing the wares. Where the current is used for the purpose, therefore, a separate solution should be used, and for this purpose Watt's suggestion to use as a stripping solution dilute sulphuric acid which will dissolve nickel readily without appreciably affecting brass, may be recommended. Under all circumstances, however, the articles should be looked at from time to time, and removed as soon as they are free from nickel. It is important, however, that the old nickel be thoroughly cleaned off, to prevent the peeling of the subsequent nickel deposit.

PLATING WITH NICKEL BY IMMERSION.

Stolba† describes the following simple process for nickel-plating without the battery, which may be usefully applied in the case of small objects. He dilutes a concentrated solution of chloride of zinc with twice its volume of water. This mixture he boils in a copper vessel, adding a few drops of muriatic acid should there appear a precipitate

* Watt, *Electro-Metallurgy* (7th Ed.), 114, *et seq.*

† *Journal Chemical Society*, xi, 465.

of basic chloride of zinc. He thereupon adds a small quantity of powdered zinc. This addition causes a deposit of zinc upon the vessel. Thereupon sufficient chloride or sulphate of nickel is added to the bath to give it a distinctly green color, and the previously cleansed articles are then immersed in the liquid in contact with zinc, and allowed to remain there for about fifteen minutes, the temperature being maintained at boiling during the operation. If the coating is found to be insufficient the articles are again immersed until a deposit of sufficient thickness is obtained. In this way, he claims to be able to coat satisfactorily, articles of zinc, cast and wrought-iron, steel, and copper.

By an analogous process described by C. Mène,* it is affirmed that metallic articles may be plated with nickel by immersing them in contact with zinc, in a boiling neutral solution of chloride of zinc, in which is contained fragments or a plate of nickel. Should the solution be acid the plating, it is asserted, will be dull. By this procedure the author claims to be able to coat articles of iron, steel, copper, brass, zinc and lead.

Where electrotypes of type or engravings are to be printed with colored inks that are disposed to become chemically affected by contact with the usual copper surface (as for example vermilion, which becomes brownish) it is customary to give the copper electrotype a thin coating of nickel in the usual manner. This nickel renders the electrotype proof against the above-named difficulty that printers experience with electrotypes not so protected.

By methods and solutions analogous to those described for nickel, electro-deposits of cobalt may be obtained. The electro-deposits of this metal equal, if indeed they do not surpass, those of nickel, in whiteness and brilliancy of lustre. The costliness of the metal, however, prevents its use for this purpose.

Black Phosphorus. — Many chemists dispute the existence of black phosphorus, regarding it as a mixture of ordinary phosphorus with traces of a metallic phosphorus which gives the color. Without denying that this may often be the case, Thenard reports an experiment which leads him to doubt that it is always so.—*Comptes Rendus*, Aug. 28, 1882. C.

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* *Chemical News*, xxv, 214.

Density of Liquid Oxygen.—M. Offret deduced, from the experiments of Pictet, the probable value of ·84 for the density of liquid oxygen. This result is not trustworthy, since it depends upon an estimate of the quantity of oxygen which still remained in a gaseous state in Pictet's apparatus. This quantity cannot be calculated, even approximately, because it requires an exact knowledge of the laws which replace the laws of Mariotte and Gay-Lussac, and the knowledge of the distribution of temperature in the gaseous mass which is found in the unchilled portion of the tube. Wroblewski finds, by an indirect method, which is described in the proceedings of the French Academy, ·895 as the most probable value of the density. Dumas considers this result as a confirmation of the views which he had announced in comparing oxygen to sulphur.—*Comptes Rendus*, July 16, 1883. C.

Critical Temperature and Pressure of Oxygen.—S. Wroblewski compresses oxygen in a vertical glass tube, bent in its upper portion so as to be plunged into liquid ethylene, and produces a vacuum above the ethylene by the aid of a powerful pump. The portion which is plunged into the ethylene has the temperature of the liquid, but in the other portion the temperature increases, after a regular law, with distance from the surface of the liquid ethylene. The temperature of the ethylene depending upon the degree of the vacuum, the pressure, which is observed when the first traces of liquid oxygen appear at the bottom of the curved and cooled portion of the tube, represents the pressure of liquefaction for the corresponding temperature. If a large quantity of gaseous oxygen is used, and the quantity of liquid oxygen increased by diminishing the volume of the unliquefied gas, it is found that in proportion as the column of liquid oxygen surpasses the level of the ethylene the pressure increases; the liquid oxygen comes into the part of the tube where the temperature is greater than that of the liquid ethylene and the observed pressure corresponds to the temperature of the tube at the place of the oxygen meniscus. If the experiment is continued, so as to increase the height of the oxygen column, a pressure is finally reached at which the meniscus completely disappears. Its place can be merely suspected from the difference of the refrangibility of the light above and below. A diminution of pressure makes the meniscus again visible. This phenomenon always reappears at the same pressure of about 50 atmos-

pheres. A similar phenomenon can be produced with carbonic acid, and by experiments in liquefying both these gases Wroblewski has arrived at —113°C. (—171·4°F.) as a first approximation of the critical temperature of oxygen. By combining this result with those which he published in a previous note (*Comptes Rendus*, xcvi, 1142), we may obtain an idea of the curve of liquefaction.—*Comptes Rendus*, July 30, 1883. C.

Analogy between Allotropic Phosphorus and Arsenic.—R. Engel has shown that when arsenic is isolated from one of its compounds, at a temperature below 300° (508°F.), it has an allotropic state which he calls amorphous. The amorphous arsenic differs from crystallized arsenic, both in density and in its point of sublimation. In these two respects amorphous arsenic approximates to white phosphorus, and crystallized arsenic to red phosphorus, the crystals being isomorphs. Both white phosphorus and amorphic arsenic are sublimed at a temperature below that of transformation. Neither red phosphorus nor crystallized arsenic can be sublimed at that temperature. The vapor of red phosphorus gives white phosphorus when it is cooled below the temperature of transformation, the vapor of crystallized arsenic gives amorphic arsenic under like circumstances.—*Comptes Rendus*, April 30, 1883. C.

Mechanical Glass Blowing.—A small apparatus was invented, in 1824, by a workman of Baccarat, to supplement the ordinary process of glass blowing. It is known as the Robinet piston, and renders useful service, but the small quantity of air which it is able to compress makes it available only for small pieces. Messrs. Appert have devised a process, in their factory at Clichy, in which they use air stored under great pressure, so as to dispense altogether with the necessity of blowing by the mouth. Glass-blowers are peculiarly susceptible to various disorders, such as diseases of the lips and cheeks, and predisposition to tumors and rupture. These affections are the more serious, because boys are often employed when the system is weakened by rapid growth. The high temperature and dry atmosphere increase the unfavorable hygienic conditions. The new process entirely suppresses mouth blowing by boys and, with rare exceptions, by adults also. The manufacture of glassware is thus ameliorated by rapidity of execution, as well as by the perfection and the large size of the pieces which are produced.—*Comptes Rendus*, June 4, 1883. C.

Modification of the Law of Isomorphism.—According to Mitscherlich, two bodies are called isomorphs when they have an analogous chemical composition, present the same crystalline form, and can crystallize together in the same crystals. Scheibler remarked the isomorphism of most of the metatungstates, although they do not contain the same quantity of water of crystallization. Marignac, in his magnificent study of silicotungstates, has shown that there is a perfect isomorphism of the acid silicotungstates of baryta and of lime, and of rhombohedric silicotungstic acid. Moreover, a small quantity of potash can replace the water in the acid, without altering the crystalline form. The same author regards certain double fluorides and oxyfluorides as isomorphs. Klein has described various isomorphs, and he proposes to adopt Marignac's modification of the law of isomorphism, viz., isomorphs either have a like chemical composition, or they have a composition which is approximately similar, while enclosing a group of common elements, or of functions chemically identical, which form much the greatest part of the weight.—*Comptes Rendus*, Oct. 30, 1882.

Origin and Periodicity of Comets.—Charles V. Zenger has examined Mädler's catalogue of cometary orbits, covering a period of 23 centuries, and finds indications of a thirteen-days' period, but the old observations are neither rigorous nor numerous enough to give the date of perihelion with precision. He has, therefore, supplemented this study with modern observations, which are sufficiently precise to furnish the date, within a day, for all the comets which have been observed between 1877 and 1882. On dividing the intervals between their successive perihelia by whole numbers, he finds unit periods ranging between 10·83 and 14·25 days, the mean value being 12·56 days, which is almost precisely that of a solar half rotation. He concludes, therefore, that the origin of comets must be intimately connected with the rotation of the sun. Supposing that there are two points upon the sun's surface, differing in longitude by about 180°, as is the case in the two centres of cyclonic disturbance on the earth's surface, the formation of comets may be explained by enormous explosions, driving the materials of the protuberances to distances of hundreds of thousands of kilometres.—*Comptes Rendus*, Jan. 8, 1883. C.

Vegetable Acclimation.—Baron de Brandis gives some curious information about the changes in the time of flowering of the *acacia*

dealbata, which was imported from Australia into India. For fifteen years after its introduction it blossomed in October. In 1860 the flowers appeared in September; ten years later in August; in 1878, during the month of July; in 1882, in June. It therefore required thirty-five years to adapt itself to the climate of India, and to modify its vegetation so that the phases would agree with the seasons of its new home.—*Les Mondes*, Aug. 4, 1883. C.

Metallization of Wood.—Rubennick's process steeps the wood in a bath of caustic alkali, for two or three days, according to its degree of permeability, at a temperature between 164° and 197° F. The wood is then placed in a second bath of hydro-sulphate of calcium, to which is added, after 24 or 36 hours, a concentrated solution of sulphur. After 48 hours the wood is immersed in a third bath of acetate of lead, at a temperature between 95° and 122° F., where it remains from 30 to 50 hours. After a complete drying, the wood thus treated is susceptible of a very fine polish, especially if its surface is rubbed with a piece of lead, tin, or zinc, and finally finished with a burnisher of glass or porcelain. It then looks like a metallic mirror, and is completely sheltered from all the deteriorating effects of moisture.—*Les Mondes*, July 28, 1883. C.

Oxycitric Acid.—Edmund Lippmann, a German chemist, has discovered in the incrustations which are deposited in the evaporators during the manufacture of beet sugar, a crystallizable body which is a very energetic tribasic acid. He regards it as identical with the product which has been described by Parvoleck, under the name of oxycitric acid.—*Les Mondes*, July 28, 1883. C.

Nervous and Intellectual Contagion.—The contagion of nervous, intellectual, and moral phenomena, is attracting the attention of French physicians. It comprises nervous tics, epileptiform disorders, insanity and other mental affections, the inclination to suicide, crime, etc. M. Rambosson, a laureate of the French Institute has published an octavo volume of four hundred pages upon the subject, which was presented to the Academy of Medicine by Baron Larry, in very complimentary terms.—*Les Mondes*, July 7, 1883. C.

Periodicity of Comets.—Prof. Zenger has examined the dates of the perihelia of the comets which have been observed since 1877,

and finds that their successive intervals are multiples of 12·56 days, or one half rotation of the sun. He deduces from this fact inferences which will be of great consequence if they are well sustained. I. The comets are produced by violent explosions, which throw the gases to hundreds of thousands of kilometres from the sun. When this projected matter encounters a cosmic mass the latter will form the nucleus of the comet, and the gaseous material will be the tail. II. The duration of the cometary revolution will be a multiple of the solar half rotation. If S is the solar rotation, and T the cometary revolution, we have

$$T = \frac{nS}{2}.$$

The value of n for Encke's comet is 95; for Brorsen's, 159; for Tempel's, 173.—*Les Mondes*, June 15, 1883. C.

Phosphoric Glass.—The phosphoric glass, which Sidot described to the French Academy, resembles ordinary glass in density and refracting power, but it is only slightly affected, if at all, by fluorhydric acid. Encouraged by the interest which was manifested in the Academy, he has continued his experiments, and has submitted a number of retorts, tubes, etc., to the Academy for examination.—*Comptes Rendus.*, June 11, 1883. C.

Choice of a Prime Meridian.—The Minister of Public Instruction submitted to the French Academy the proposal of the United States government for an international congress, to select a universal prime meridian and to agree upon a common standard of time. M. Faye, on behalf of the committee to whom the subject was intrusted, cordially recommended the acceptance of the proposal and the appointment of scientific representatives of the various interests, of astronomy, navigation, telegraphy, geography, and terrestrial physics. M. de Chancourtois proposed a decimal division of the day and of the circumference of the globe, somewhat similar to that which was adopted after the first French Revolution, so as not only to adopt a universal hour but also a universal scale for the absolute measure of time. He thought that the prime meridian should either be that of Ptolemy or that which passes through Behring's straits, both of which would be free from any competition of national pride, since they traverse no habitable lands.—*Comptes Rendus*, Jan. 15, 1883. C.

Principle of the Telephone. — Prof. Govi has contrived an experiment which he calls a demonstration of the principle of the telephone. He takes two tuning forks, which he puts in close proximity to two magnets, each of which is surrounded by a copper wire which serves to connect them together. On sounding one of the tuning forks with a bow, the vibrations are transmitted by the wire and are reproduced in the other fork.—*Les Mondes*, March 17, 1883. C.

CORRESPONDENCE.

To the Committee on Publication.

In *Science* of January 25th last I find the following, in a communication by Professor Eddy, referring to the Second Law of Thermodynamics, as published in your JOURNAL: "In my reply in the same Journal for June, 1883, I showed the fallacy of his objection. So far as I know, Professor Wood has taken no notice of that reply, and now completely ignores it."

Having been called to an account in this public manner, I may be pardoned, at this late day, for saying that I intentionally ignored it, for it contained no reply to my argument.

Yours truly,

DE VOLSON WOOD.

To the Committee on Publication:

GENTLEMEN:—In the JOURNAL OF THE FRANKLIN INSTITUTE for January, 1884, I have noticed a criticism by Mr. Hugo Bilgram, on my proposition, published in the December issue of 1883, page 471, and it seems to me that your correspondent, in quoting from Dr. Grashof, that a level surface is such "that the resulting force of all attractions is in all points normal to the same," should have observed that this same force must necessarily act in a normal direction upon the contiguous level surface, for otherwise there would be a tangential component disturbing the supposed equilibrium of the liquid mass.

This justifies my tacit assumption that the inner surface of the uniform and exceedingly thin stratum of liquid which is in my demonstration supposed to become like a shell, is a surface of level, and consequently my conclusion is unavoidable. L. D'AURIA.

Philadelphia, February 20, 1884.

List of Books added to the Library during October, November and December, 1883.

Academie des Sciences. Tables Générales des Comptes Rendus. Tomes. 1–61, in 2 Vols. Paris, 1853 and 1870.

Academie Royale des Sciences, Lettres et Beaux-arts de Belgique. Tables Générales des Bulletins. 2°. Serie. Tomes 21–50. 1867–1880. Bruxelles, 1883. From the Academy.

Adams, H. Notes in Mechanical Engineering. London. Spon, 1883.

Adjutant General of Pennsylvania. Annual Report. 1866. Harrisburg.

Allentown, Pennsylvania. Annual Reports of the Water Commissioners for 1876, 1877, 1879–1882. From the Commissioners.

American Academy of Arts and Sciences. Proceedings. Vol. 10. 1882–1883. Boston. From the Academy.

American Agriculturist. Vols. 1, 2, 3, 5–10, inclusive. New York.

American Association for the Advancement of Science. Reports of Proceedings of 7th, 13th to 20th, and 27th to 31st Meetings. From the Association.

American Ephemeris and Nautical Almanac, for 1884 to 1886. Washington. From the Superintendent.

American Exchange and Review. Vols. 1 to 4 and 6 and 7. From John A. Fowler. Editor. Philadelphia.

American Geographical and Statistical Society. Journal. Vol. 1. New York.

American Geographical Society. New York. Journal. Vols. 3 to 13. 1870–1881. From the Society.

American Iron and Steel Association. Bulletin No. 27. August 24, 1881. Vol. 15. From the Secretary.

American Journal of Microscopy. January, March, April and June, 1881. From Dr. W. H. Wahl.

American Machinist. Nos. 4, 6, 8, 10 and 12 of Vol. 1, 1878. New York. From the Publisher.

American Monthly Microscopical Journal. June and August, 1881. From Dr. W. H. Wahl.

American Pharmaceutical Association. Proceedings. 1871 to 1881. Philadelphia. From J. M. Maisch. Editor.

American Philosophical Society. Catalogue of the Library. Part I. 1863. Philadelphia. From the Society.

American Philosophical Society. Transactions. New Series. Part 1. Vol. 16. Philadelphia, 1883.

American Printer: a Manual of Typography. Philadelphia, 1883. From MacKellar, Smiths and Jordan, Publishers.

American Water Works Association. Constitution and By-laws, with Proceedings of 1st and 2d Annual Sessions. 1881 and 1882. From J. H. Decker, Secretary.

American Water Works Association. Annual Reports. 1st to 3d. 1881–83. From J. G. Briggs, Terre Haute, Indiana.

Army Register. Official. January, 1876. Washington.

Ashburner, Chas. A. Anthracite Coal Beds of Pennsylvania. Philadelphia, 1882. From the Author.

Ashburner, Chas. A. New Method for Estimating the Contents of Highly Plicated Coal Beds as applied to the Anthracite Fields of Pennsylvania. From the Author.

Ashburner, Chas. A. New Method of Mapping the Anthracite Coal Fields of Pennsylvania. 1881. From the Author.

Astronomical and Meteorological Observations made in 1879. Washington, 1883. From the United States Naval Observatory.

Astronomical Observations made under the Direction of M. F. Maury, 1845. Washington, 1851. From the Nautical Almanac Office.

Atlantic and St. Lawrence Railroad Company. Annual Reports, 1844–1883. Portland. From the Company.

Auditor-General's Report on Railroads of Pennsylvania. 1863, 1864 and 1866. Harrisburg.

Bailey, R. A. United States National Loans, 1776–1880. Washington, 1882. From the Treasury Department.

Baltimore and Ohio Railroad Company. Annual Reports, 1859–1882. From the Secretary.

Baltimore, Md. Annual Report of the Water Department to the Mayor and Council for 1882. From B. K. Martin, Chief Engineer.

Bangor and Piscataquis Railroad Company. Reports of the Directors. 1876–1882. From the Company.

Banker's Magazine. April, 1867; August, 1868. New York. From I. S. Homans.

Banks and Saving Institutions of Pennsylvania. Reports for 1880. Harrisburg. From Hon. G. W. Hall, House of Representatives.

Bay City, Mich. Annual Reports of the Superintendent of Water Works, 1875, 1877–1882. From the Superintendent.

Berthelot, M. P. E. Explosive Materials. New York. Van Nostrand. 1883. From the Publisher.

Binghampton. Annual Reports of the Board of Water Commissioners for 1876, 1878–1880 and 1882. From the Commissioners.

Blair, H. Lectures on Rhetoric and Belles Lettres.
From B. B. McKinley.

Blake Manufacturing Company. Illustrated Catalogue of Improved Steam Pumping Machinery. New York.
From the Company.

Blodget, L. Census of Manufacturers of Philadelphia, 1883.
From Charles Bullock.

Board of Agriculture of Pennsylvania. Annual Report for 1882. Harrisburg, 1883.
From Hon. G. W. Hall, House of Representatives.

Board of Education of First School District. Philadelphia. Annual Reports. 1821–1883. From the Board.

Board of Health. Philadelphia. Annual Reports for 1860 and 1877. From His Honor the Mayor.

Board of Public Education. Sixty-fourth Annual Report. Philadelphia, 1883. From the Board.

Board of Public Works. Chicago, Ill. Tenth Annual Report. 1870–1871. From the Board.

Board of Supervising Inspectors of Steam Vessels. Proceedings of the 30th Annual Meeting. 1882. Washington.
From the Supervising Inspector General.

Board of Trade of Philadelphia. Annual Reports. 1865–1882.
From G. L. Buzby, Secretary.

Boston, Concord and Montreal Railroad. Twenty-seventh to Thirty-seventh Annual Reports of the Directors. 1873–1883.
From the Company.

Boston Journal of Chemistry. Missing Nos. required to complete Serial. Boston.

Boston, Mass. Annual Reports of the Cochituate Water Board to City Council for 1855, 1857, 1858, 1860–1869 and 1871, 1872 and 1874–1876.

Annual Reports of the Water Board for 1878 to 1883.

Description of the Water Works. Chicago, 1878.

Report of the Medical Commission upon the Sanitary Qualities of Sudbury, Mystic, Shawshine, and Charles River Waters. Boston, 1874.

Report of the Cochituate Water Board. October 31, 1873. Boston, 1874.

Report of Joint Standing Committee on Water, with Report of City Engineer. Boston, 1874.
From A. Febs, Chief Assistant City Engineer.

Special Report of the Water Board. Sept. 6, 1883.

Boston Public Library. Annual Reports of the Trustees. 1854–1877. Boston. From the Library.

Brevêts d'Inventions. Tomes 104 et 105. Paris, 1883.
From Ministre du Commerce.

Brewer, Distiller and Wine Manufacturer. Philadelphia: P. Blakiston, Son & Co. 1883. From the Publisher.

Bridgeport Hydraulic Company. Reports of the Superintendent to Directors. 1876, 1879, 1881 and 1883.
From the Superintendent.

Briggs, R. Steam Heating. New York. Van Nostrand. 1883.
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(To be continued.)

Book Notices.

KINEMATICS; OR, MECHANICAL MOVEMENTS. MacCord. 336 pages. 8vo. New York: John Wiley & Sons, 1883.

Unless it is the intention of the author to make the present volume only one of a very large number of volumes, it would seem much better to call it what it is, a treatise on gearing.

On opening the book one is at once pleasantly impressed by the great neatness and number of the drawings. Moreover, these drawings are not slavish copies from unacknowledged sources, such as we too often see, but are many of them original, and where they are not new, are great improvements upon the rude outlines given by Willis and Rankine. It is indeed impossible to have too many or too good drawings for such a work as this.

There is another point about the book worth noting. Internal evidence shows in every chapter that a vast amount of work not shown to the careless reader has been done. The minutest details have evidently been given much thought, and possibly, experimental proof. There has been no careless generalizing after the manner of Rankine. Indeed, we might say, that there is no generalizing at all in the book.

This is a decided advantage for the mechanic who only uses the book for the special mechanism of which he desires to avail himself; it may be regarded as a deficiency where we use it as a text-book for students. This deficiency can well be excused by any person who has had to work up a subject thoroughly elsewhere in order to grasp the meaning of Rankine's vague and vast generalizations, or who has found himself left at the gateway of practical application by Willis, with perhaps the severest work yet to be done before he realizes what he desires to accomplish.

We fear that too much credit is given to those who in the past have recorded a new idea and have left others to determine limitations and exceptions which will render it useful or correct in its application. The *really* new ideas are few, and most of our great authorities are men characterized by a facility of expression which has enabled them to collate and arrange what is floating in the intellectual atmosphere of of their times; they have been bookkeepers, rather than active, busy mechanics or men of original thought, and seem rather to have great

power of absorption and assimilation than of original thought. Few, indeed, are the really original thinkers.

Prof. MacCord deserves credit for independence in having subjected authority to carefnl scrutiny before accepting it. His adherence to graphical methods and to simple geometrical and algebraic methods will be a great relief to the busy man of the shop, yet it is a serious defect in the classroom.

It would have been better, and have given students a broader comprehension had Prof. MacCord shown, as can be shown, that equations can be established, from the consideration of two axes in space joined by a common normal, which will make one group of cylinder, hyperboloid and cone, and admit of one general graphical solution if necessary.

It would have been easy to call the attention of students to the fact that the family of hyperboloidal gears are characterized by teeth whose directrices lie parallel to, or are coincident with, the generatrix of their pitch surfaces and are straight, and that spiral gears of all kinds differ only in that the directrix of the tooth forms an angle with the generatrix of the surface.

The treatment of cutters given is elaborate and does give a clear idea of what cutters are and what they are intended to produce.

Pratt & Whitney receive a puff, and Brown & Sharpe a criticism, which should not appear in a scientific work. Really Saxton deserves the credit of having devised what seems to have been awarded to Pratt & Whitney and Brown & Sharpe.

Every mechanic knows that while probabilities of error exist in Brown & Sharpe's method of transference of shape of teeth to throat tools, still, milling the edge of a cutter leaves it without clearance in the case of Pratt & Whitney, and this latter point is not mentioned.

One ought to be fair if one assumes the role of umpire in business matters.

Pages 186 to 195 are devoted to the determination of a series of cutters by graphical methods. The condition that the addendum to a cut tooth is one diametral pitch would render this solution more exact and brief analytically. For instance, if we call α the angle between a line drawn through the centres of pitch and describing circles and a line drawn from the centre of the describing circle to the outside corner of the epicycloidal tooth, we have the following equations for computing

accurately the thickness of a cutter for any pitch describing circle and number of teeth.

$$\text{Cos. } a = 1 - \frac{8(n+1)}{d(2n+d)}$$

in which n = number of teeth in wheel desired and d = number of teeth in straight flank pinion.

The thickness of cutter T then is

$$T = \frac{n+2}{p} \text{ sin. } \left[\frac{90^\circ}{n} + \frac{d}{2n}a - \text{sin.}^{-1}\left(\frac{d}{2(n+2)} \text{ sin. } a\right)\right]$$

in which $\frac{1}{p}$ = the diametral pitch.

If we assume this to be 1, and compute the series, we have only to divide by the number of teeth per inch to obtain the exact thickness of cutter for any pitch and for any system whatever that we may have fixed upon.

There is an unpleasant affectation of familiarity of speech in parts of the book that could well be spared. *Vide* p. 220, for instance.

"The fallacy above mentioned, if crushed by theory, is pulverized by practice."

The great excellence of this work lies in its drawings and the microscopic thoroughness of its scrutiny of details.

It is far more valuable to the practitioner than any yet written in English and is well worth reading by every student of mechanism.

The faults are trifling and its merits many.

W. D. M.

ELECTRICITY, MAGNETISM AND ELECTRIC TELEGRAPHY; a Practical Guide and Handbook of General Information for Electrical Students, Operators and Inspectors. By Thomas D. Lockwood. New York: D. Van Nostrand, publisher.

This is a volume of 377 pages, containing a large amount of practical information clearly and concisely presented. About 150 pages are devoted to practical telegraphy and telephony, and the chapter on electrical measurements is also written with special reference to its application to telegraphy. The information is given in the form of question and answer, and the questions are just such as would be asked by an unscientific person practically engaged in the utilization of the mysterious forces of electricity and magnetism to give him a general

knowledge of the subject. It is what it professes to be, a handbook, and is a good one. There is a noticeable absence of anything like "padding," and there is a freshness in the method of presenting the underlying principles of the science which makes the volume a very attractive one. E. A. S.

SATURATED STEAM THE MOTIVE POWER IN VOLCANOES AND EARTHQUAKES; Great Importance of Electricity. By R. E. Peacock, C. E. F. G. S. Second edition, improved. London: E. & F. N. Spon, 16 Charing Cross; New York: 44 Murray street. 1882. Pp. 198.

The improvements appear to consist chiefly in a supplement of addenda and errata, in number about thirty, and in space fifty pages. The author refers to and copies a review of his first edition, which he states appeared in the January number for 1883 of "that first-class scientific publication, the *Philosophical Magazine*," with which he expresses himself "on the whole gratified," and which says: "Evidence is quoted from various authorities to the effect that (1) free hydrogen has been detected in the flames issuing from certain volcanoes; (2) the temperature of the combustion of oxygen with hydrogen is 14·541°F.; (3) clouds of steam are frequently ejected from volcanoes; (4) the pressure of saturated steam at 14·541°F. is about one million tons per square inch." Hence the conclusion that "there is no other terrestrial force at all approaching to saturated steam in power and magnitude," and the question (about volcanic eruptions and earthquakes). Will any man venture to deny that saturated steam was the active agent on these occasions? answered, further on, thus: "This steam *necessarily* causes earthquakes and volcanoes, for how is it possible that so very vast a power can remain idle?"

After referring to the author's experience on a runaway horse, which he cites in support of his theory, the reviewer proceeds: "In other cases, statements of fact are generally freely supported by quotations from authority; the author even thinks it as well 'to prove by a quotation from 'Chemistry' that, since air and water were present in the volcano of Java, oxygen and hydrogen were necessarily present also.'"

The author stands by the propriety of this quotation, since he says, in a foot-note: "It is not quite every reader who knows what gases water is composed of. Hence the reference to 'Chemistry.'"

The passage in question may be presented as a specimen of the general style of the work. "We will now prove by a quotation from 'Chemistry' that, since both air and water were present in the volcano of Java, oxygen and hydrogen were necessarily present also. For these are constituents of air and water. Moreover, we cannot doubt that electricity was present also to decompose them into their constituent elements. For it is notorious that electricity has often been seen active in volcanoes."

The review concludes: "The style is not always clear."

The special point sought to be enforced in this edition is that the moving force is "saturated electric steam," as to which the author specially expresses himself in a postscript, on page 184, though in what manner the steam becomes electric he is not at all clear; and, though he speaks frequently of electricity and of electric steam, it would evidently give him much trouble to formulate his views upon the subject in accordance with any accepted theory.

The author has industriously compiled a disjointed mass of information upon the subject of earthquakes and volcanoes, but it is difficult to trace his deductions from them; that steam, "electric" or other, is sufficient in force to effect a volcanic explosion, or an earthquake, is plain, without argument; that it is the cause of them, and especially that "electric" steam is the moving agent, is not demonstrated by his book.

G. M. E.

ELECTRICITY IN THEORY AND PRACTICE; or, the Elements of Electrical Engineering. By Lieut. Bradley A. Fiske, U. S. N. New York: D. Van Nostrand. Philadelphia: H. Carey Baird & Co.

"The design of this book is to form a bridge between works written on the theory of electricity and works treating of the practical applications;" or more particularly to "explain the theory of the practical applications." The range of subjects treated are Magnetism, Frictional Electricity, Work and Potential, Voltaic Batteries, Laws of Currents, Secondary or Storage Batteries, Thermo-Electric Batteries, Electro-Magnetism, Induction Currents, Electrical Measurements, Telegraphy, The Telephone, The Electric Light, Electric Machines, Electro-Motors, Electrical Distribution of Power Meters, and Electric Railways.

Those parts of the book devoted to descriptions of applications particularly deserve praise for the elegant clearness and neatness of treatment. There is absence of prosy and muddled descriptions, while

salient points are presented with much vigor. Indeed, the author must be complimented upon the general clearness of his style in presenting the elementary features of Electrical Engineering. The happy omission of the unnecessary, inclines us to overlook the omission of several points one would like to see treated in a work of this character. We may, however, suggest that the actual "theory" of the book might with advantage to many readers have been carried further. We should perhaps have had a fuller explanation of the methods of measurement as applied to Magnetism, and at least a reference to forms of Electric Induction Machines later than the Holtz. The description of Thermo-Electric Batteries would not lose by mentioning, along with the many of perhaps less importance, those of the Clamond and other useful types. Then the chapter on Practical Measuring Instruments might without detriment have included descriptions of Sir Wm. Thomson's Graded Galvanometers and an inkling of the theory of their construction.

As the work stands it is useful and valuable, and will no doubt find many pleased and profited readers. M. B. S.

Franklin Institute.

[*Proceedings of the Stated Meeting, Wednesday, February* 20, 1884.]

HALL OF THE INSTITUTE, Feb. 20, 1884.

The meeting was called to order at the usual hour, with the President, Mr. Wm. P. Tatham in the chair. There were present 198 members and 19 visitors. The minutes of the January meeting were read and approved. The Actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting held Wednesday, Feb. 13th, 11 persons had been elected to membership.

Mr. S. Lloyd Wiegand presented a further communication, respecting the use of cast iron in steam boilers, illustrating the same by the bursting by hydrostatic pressure of a model of the exploded "Gaffney" steam boiler. The paper was discussed by Messrs. J. W. Nystrom and the author, and will appear in the JOURNAL.

The Secretary's report included remarks on the Tunnel under the Mersey, the state of the Bessemer Steel Industry in the United States, the insufficiency of Life Saving Appliances on Shipboard, the Cause of the Red Sunsets, and a description of several mechanical inventions,

viz.: the Fulton Steel Pulley, shown on behalf of the Indianapolis Machine and Bolt Works. It is claimed for this pulley that it combines strength and lightness to an unusual degree. It consists of three parts—the rim, the disk and the hub. The rim and disk are of steel, and the hub of malleable iron, a special feature of the invention residing in the corrugation of the steel disk, which is affirmed to add greatly to the strength of the pulley. These corrugations are done in a press, in which the hot steel sheet is placed for the purpose. The Metzler & Burrell Improved Railway Signal Lantern, for use by trainmen, gatemen, etc., has two globes, of different colors, joined together at the centre by bayonet locks and catch. The handle passes through the centre of the lantern, and is attached firmly to the lamp, forming an axis upon which the lantern may revolve. Only the upper half of the lantern is illuminated, the lower half being darkened by the body of the lamp. The handle catches to the rim of the half that is uppermost. Thus, if a white or clear light is showing, and it is necessary that a signal of danger, or red light, be instantly given, a revolution of the lantern (which can be made in less than one second) gives the red light, or danger signal.

In addition there were shown and described an improved fire escape invented by Mr. John Harper, of Duncannon, Pa.; the Gardner & Woodbridge Threading Tool, made by the Hartford Tool Company; an improved door knob, dispensing with the side or set screw, made by the Yale and Towne Manufacturing Company, of Stamford, Conn., and an improvement in car-couplers, invention of Aaron Park, of Ottumwa, Iowa.

Mr. David Cooper exhibited a fine suite of specimens of Direct Life-size Camera Portraits, illustrating the progress lately made in dry-plate photography. These pictures were taken with dry plates prepared by the Eastwick Dry Plate Company, of New York.

Mr. Washington Jones, seconded by Mr. G. M. Eldridge, offered the following preamble and resolutions, which were adopted:

WHEREAS, The American Society of Civil Engineers, and the American Society of Mechanical Engineers are urging upon Congress the importance to the Mechanic Arts of a thorough investigation of the strength and other qualities of materials used for structural purposes; and

WHEREAS, The Franklin Institute, in the year 1836–1837, by its Committee on the Explosions of Steam Boilers, conducted a series of experiments made at the request of the Treasury Department of the United

States, and submitted a valuable report upon its "examination of the strength of the materials employed in the construction of steam boilers"* made with such appliances as were then obtainable; and

WHEREAS, The Franklin Institute, believing that a continuance of such investigations, with the improved means of the present time, will prove to be of much benefit to the large and diversified industries of the country; therefore be it

Resolved, That the petition of the Franklin Institute be presented to Congress, respectfully asking for the "appointment of a Committee of Experts for the testing of iron, steel and other building material," with a suitable appropriation for its expenses.

Mr. Samuel Sartain offered an amendment to the by-laws, *i. e.*, to add, at the close of Article III, Section 3, the following words: "*Provided*, that no payment less than the full contribution for one year shall entitle the member to admission to the Exhibitions." It was ordered that the proposed amendment take the usual course prescribed by Article XVI.

The following were named by the President to constitute the Standing Committees of the Institute for the year 1884:

On the Library.—Andrew Blair, Charles Bullock, J. Howard Gibson, Fred'k Graff, Wm. D. Marks, S. H. Needles, Isaac Norris, Jr., Chas. E. Ronaldson, Lewis S. Ware, Jos. M. Wilson.

On Minerals.—Clarence S. Bement, Persifor Frazer, F. A. Genth, Edwin J. Houston, George A. Koenig, Otto Lüthy, E. F. Moody, H. Pemberton, Jr., Theo. D. Rand, Wm. H. Wahl.

On Models.—Edward Brown, H. L. Butler, C. Chabot, L. L. Cheney, N. H. Edgerton, John Goehring, Morris L. Orum, Chas. J. Swain, John J. Weaver, S. Lloyd Wiegand.

On Arts and Manufactures.—J. Sellers Bancroft, Geo. Burnham, Cyrus Chambers, Jr., Geo. V. Cresson, Wm. Helme, Wm. B. Le Van, Alfred Mellor, J. W. Nystrom, Henry Pemberton, John J. Weaver.

On Meteorology.—David Brooks, J. B. Burleigh, Wm. A. Cheyney, J. A. Kirkpatrick, T. B. Maury, Isaac Norris, Jr., Hector Orr, Alex. Purves, M. B. Snyder, Wm. H. Wahl.

On Meetings.—Charles H. Banes, A. B. Burk, G. Morgan Eldridge, Fred'k Graff, Washington Jones, J. E. Mitchell, H. W. Sellers, M. B. Snyder, Wm. H. Thorne, John J. Weaver.

Adjourned. WM. H. WAHL, *Secretary.*

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* See Report of Committee on Steam Boiler Explosions, JOUR. FRANKLIN INSTITUTE, Vols. 19 and 20, new series.